



**State of Louisiana
Coastal Protection and Restoration Authority**

**2018 Operations, Maintenance, and
Monitoring Close-Out Report**

For

**GIWW (Gulf Intracoastal Waterway) to
Clovelly Hydrologic Restoration (BA-02)**

State Project Number BA-02
Priority Project List 1

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Lafourche Parish

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Preface

The information presented in this report includes the annual project inspection from April 2017 as well as data collected from July 1997 through November 2017. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project is sponsored by Natural Resources Conservation Service (NRCS) and Coastal Protection and Restoration Authority of Louisiana (CPRA) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List 1).

This is the final comprehensive report in a series of five Operations, Maintenance, and Monitoring (OM&M) reports. The end of life for this project was projected for 2020 based upon the end of construction date for Construction Unit 2 in October 2000. Monitoring ended in November 2017 due to the expiration of the 20 year land rights agreement with a joint decision between NRCS and CPRA not to renew the agreement.

I. Introduction

The GIWW to Clovelly Hydrologic Restoration (BA-02) project is located in Lafourche Parish, Louisiana, southeast of the Gulf Intracoastal Waterway (GIWW), east of Bayou Lafourche, and north of the Breton Canal, and west of Little Lake (figure 1). The project area totals 14,840 acres (6,006 hectares) and is part of the last contiguous marsh tracts in the Barataria Basin.

Within the GIWW to Clovelly Hydrologic Restoration (BA-02) project the average rate of change from marsh habitat to non-marsh habitat (including wetland loss to both open water and commercial development) has been increasing since the 1950's. The mean wetland loss rates were 0.36%/year between 1945 and 1956, 1.03%/year between 1956 and 1969, and 1.96%/year between 1969 and 1980 (Sasser et al. 1986). The project area gained 0.47%/year between 1993 and 1996, before project construction (USGS 2004). Impacts from the numerous oilfield canals constructed in the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project area include changes in hydrology, marsh impoundments, reduction in sediment accretion, and saltwater intrusion (Turner et al. 1984; Swenson and Turner 1987; Wang 1988; Turner 1990). The Clovelly Canal is connected to Little Lake on the eastern end and likely facilitates the transport of more saline waters from Little Lake to western regions of the project area.



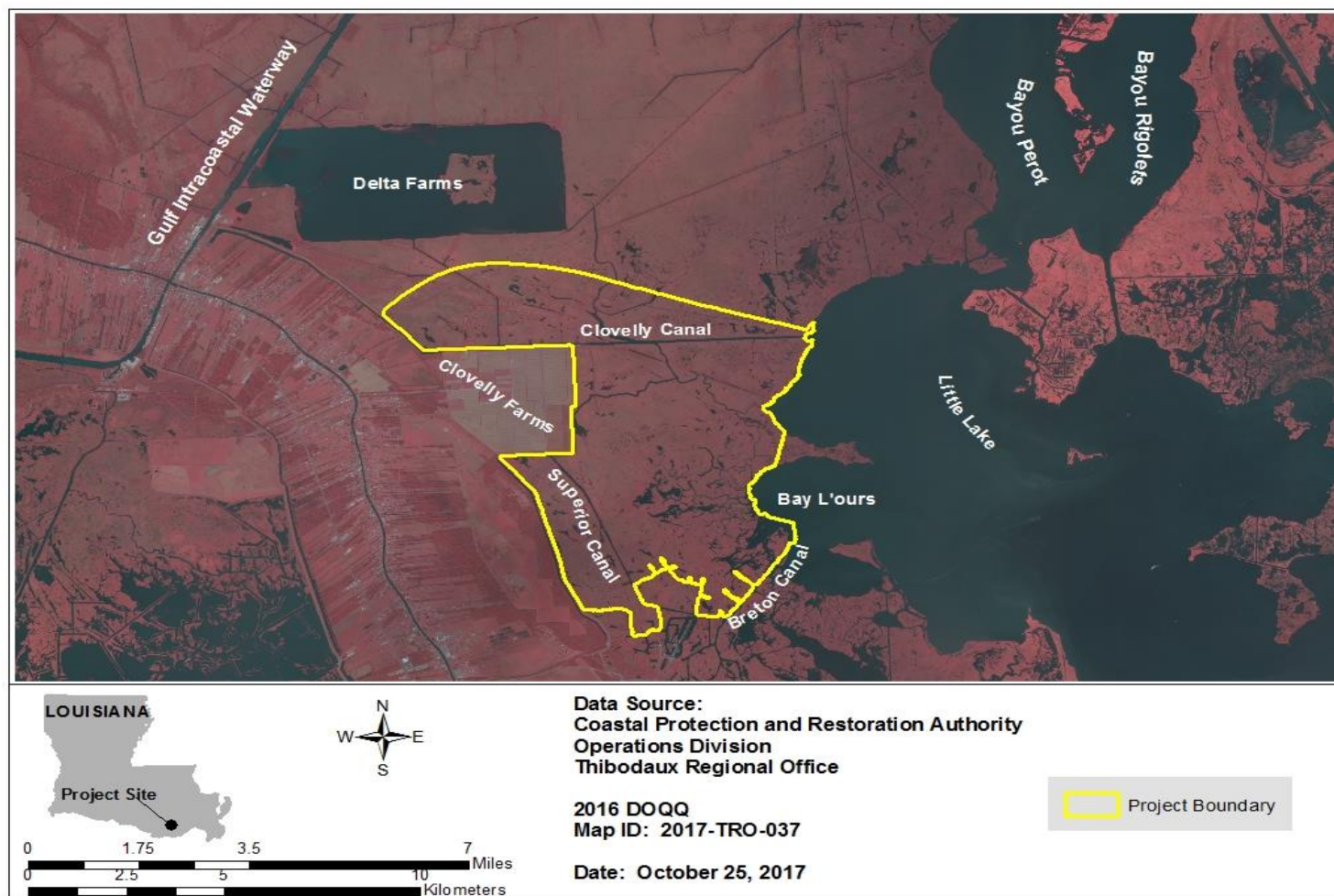


Figure 1. Location map with project boundary for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Since 1949, marsh types have changed throughout the project, especially in the southern area. The entire project area was characterized as fresh marsh and floating three-corner grass by O'Neil in 1949 (Coastal Environments, Inc. 1989). Beginning in 1968 areas of intermediate and brackish marsh encroached into the project area from the east, and by 1978, the project area contained almost entirely intermediate marsh with some brackish marsh along the Little Lake shoreline. In 1988, none of the project area was characterized as fresh marsh (Chabreck et al. 1968; Chabreck and Linscombe 1988), but the 1997 survey showed some pockets of fresh marsh in the northwest portion with the remainder of the project area as intermediate marsh. In 2001, the areas of fresh marsh in the northwest remained, some brackish marsh occurred in pockets in the southeast, but intermediate marsh was still predominate. In 2007, the entire project area was intermediate marsh (Sasser et al. 2007). Whether the changes in these areas were due to an increase in salinity, a change in the water level regime, or a combination of the two is unclear. Increasing land loss rates for the Cut Off area (1932-1985: 0.10%; 1983-1990: 0.25%) (Dunbar et al. 1992), along with the changes in marsh types, raised concerns that the quality of the marsh was declining and marsh would be converted to open water. Based upon the 2013 Coastwide Reference Monitoring System (CRMS) Wetlands helicopter survey data, the northern and central portions of the project area were primarily intermediate marshes, while the southern portion was a mix of intermediate to brackish marshes (CPRA May, 2018). The 2016 monitoring data indicates that the project was dominated by *Spartina patens* (Ait.) Muhl. (marshhay cordgrass).

The project objective is to protect intermediate marsh in the project area by restoring natural hydrologic conditions that promote greater use of available freshwater and nutrients. This will be accomplished through structural measures aimed at limiting rapid water level change, slowing water exchange through over-bank flow, reducing rapid salinity increases, and reducing saltwater intrusion (Lear 2003).

Construction of project features occurred in two construction units. Construction Unit No. 1 was completed in October 1997, and Construction Unit No. 2 was completed in October 2000. CPRA and NCRS have agreed that the twenty-year (20-yr) project life would be based on the end of construction date for Construction Unit 2 in October 2000.

Project features include (CPRA et al. 2002):

Construction Unit No. 1 (04/21/1997 – 10/06/1997)

- Construction of three (3) fixed crest rock weirs with boat bays, consisting of 200 pound class rock riprap cap on top of geotextile with a crest elevation approximately 3.8 to 4.0 ft (1.2 m) NAVD88, and a crest width approximately 8 to 8.9 ft (2.6 m) (figure 2; Structures 2, 4, and 7). Weir lengths varied depending upon their locations.

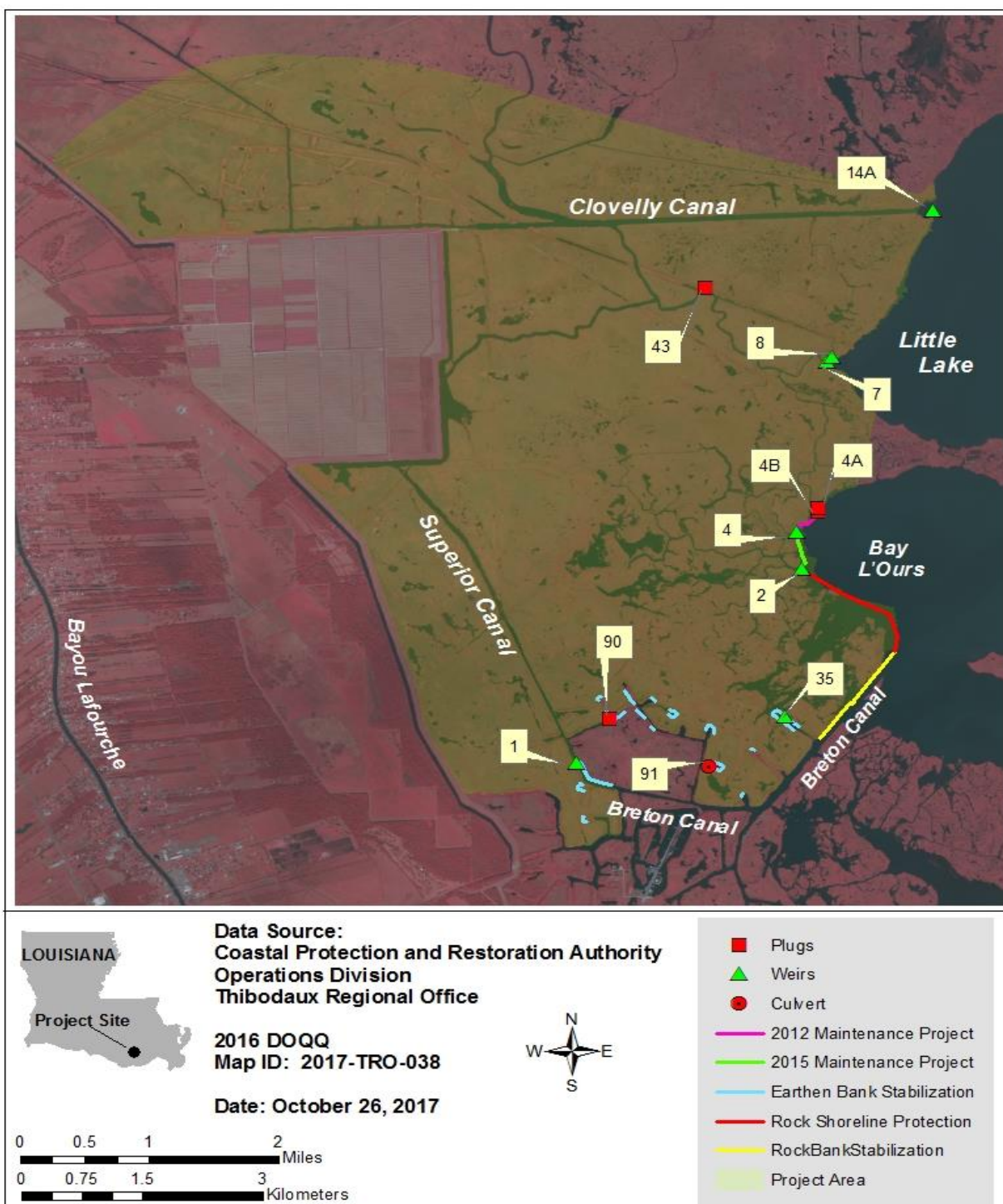


Figure 2. Infrastructure map for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

- Construction of a rock riprap channel plug on top of geotextile. The crest width was 8.0 ft (2.44 m) with an elevation of 2.45 ft (0.75 m) NAVD88 (figure 2; Structure 43).
- Construction of one 102 linear ft (36.6 m) rock-filled channel plug with a crest elevation of 3.2 ft (1.0 m) NAVD88, with a 36 inch diameter 10 gauge pile supported corrugated aluminum culvert through the plug embankment, and a 36 inch aluminum flap gate (figure 2; Structure 91).
- Construction of one 65 ft. (19.8 m) rock riprap fixed crest weir with an 8 ft (2.4 m) wide boat bay. The crest was set at +1.0 ft (0.304 m) above marsh level. The invert of the boat bay was set at -3.5' (-1.06 m) (figure 2; Structure 8).

Construction Unit No. 2 (04/14/2000 – 10/13/2000)

- Construction of approximately 5,665 linear ft (1,727 m) of lake-rim rock shoreline protection consisting of 650 pound class rock riprap on top of geotextile with a design crest elevation of +2.0 ft (+0.6 m) and an average constructed crest elevation of 3.0 ft (0.9 m) NAVD88, and a crest width of 4 ft (1.2 m), along the southwestern shorelines of Little Lake, Bay L'Ours, and Brusle Lake (figure 2).
- Construction of approximately 5,023 linear ft (1531 m) of rock bank stabilization consisting of 200 pound class rock riprap on top of earthen and rock fill on top of geotextile with a design crest elevation of +2.0 ft (+0.6 m) NAVD88, an average constructed crest elevation of +3.0 ft (+0.9 m) NAVD88, and a crest width of 4 ft (1.2 m), along the northern shoreline of Breton Canal (figure 2).
- Construction of approximately 11,711 linear ft (3,570 m) of earthen bank stabilization on top of geotextile with a design crest elevation of 2.0 ft (0.6 m) NAVD88, an average constructed elevation of +3.0 ft (+0.9 m) NAVD88, and a crest width of 4 ft (1.2 m) to 14 ft (4.3 m), on the banks of man-made canals in the southern portion of the project area (figure 2).
- Construction of one 263 linear ft (80 m) fixed crest weir with a 20 ft (6.1 m) barge bay consisting of rock riprap with a crest elevation of 4.0 ft (1.2 m) NAVD88 and the invert of the barge bay set at -6.4 ft (-1.9 m) NAVD88 (figure 2; Structure 1).
- Construction of one 1,665 linear ft (507.5 m) fixed crest rock riprap weir with an 80 ft (24.4 m) barge bay, with a crest elevation of 4.0 ft (1.2 m) NAVD88 and the invert of the boat bay at an elevation of -6.5 ft NAVD88 (-2.0 m) (figure 2; Structure 14A).
- Construction of one 511 linear ft (155.8 m) rock riprap channel plug with a crest elevation of 3.5 ft (1.1 m) NAVD88 (figure 2; Structure 4B).

- Construction of one 60 linear ft (18.3 m) rock plug 2.4 ft (0.73 m) above marsh elevation on geotextile with 8 ft (2.44 m) top with 3:1 side slopes (figure 2; Structure 4A).
- Construction of one 213 linear ft (64.9 m) rock riprap channel plug with a crest elevation set at 4.0 ft (1.2 m) NAVD88 (figure 2; Structure 90).
- Construction of one 80 linear ft (24.4 m) sheet pile variable crest weir with a 10 ft (3 m) wide variable crest section containing a 10 ft (3 m) wide stop log bay containing 12 stop logs. The stop logs can be adjusted from 1.0 ft to -3.0 ft (0.3 m to -0.9 m) NAVD88 using a movable crane with a hand winch. The fixed crest section of the structure was constructed with earthen wing walls to a crest elevation of 2.89 ft (0.88 m) NAVD88 on either side of the weir (figure 2; Structure 35).

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of performing an annual inspection is to evaluate the constructed project features, identify any deficiencies, prepare a report detailing the condition of such features, and to recommend corrective actions needed, if any. Should it be determined that corrective actions are needed, CPRA shall provide, in report form, a detailed cost estimate for engineering, design, supervision, inspection, construction contingencies, and an assessment of the urgency of such repairs (CPRA et al. 2002). The annual inspection report also contains a summary of maintenance projects undertaken since the constructed features were completed and an estimated project budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year budget projections for operation and maintenance of the GIWW to Clovelly Hydrologic Restoration (BA-02) project are shown in Appendix B. A summary of past operation and maintenance projects undertaken since the completion of the project are outlined in Section II.d of this report.

An inspection of the GIWW to Clovelly Hydrologic Restoration Project (BA-02) was held on April 20, 2017. In attendance were Darin Lee, Elaine Lear, and Brian Babin with CPRA, Quin Kinler, Cody Colvin and Doug Baker with NRCS, and Randy Moertle representing the landowners. All attendees met at the Clovelly Canal Boat Launch and the inspection began at approximately 8:30 am and concluded at 11:00 am. The water level was recorded at gauge BA02-57 located in Superior Canal and was determined to be 1.6' NAVD88 at 10:30am.

The field inspection included a complete visual inspection of all constructed features within the project area. Photographs of all project features were taken during the field inspection and are

shown in Appendix A. Staff gauge readings, where available, were documented and used to estimate approximate water elevations, elevations of rock weirs, earthen embankments, lake-rim dike and other project features. One foot was added to the water depths obtained from the handheld fathometer due to the instrument being approximately 12 inches below the water line when the depths were taken.

b. Inspection Results

CONSTRUCTION UNIT NO.1

Structure 2 – Fixed crest rock weir with boat bay

Structure 2 was recapped with 130 lb class riprap to its original design elevation as part of the 2012 Maintenance Project. Soundings taken during the inspection along the boat bay section of the weir averaged 5.0 ft (1.52 m) depth. Based on the staff gauge reading in Superior Canal and soundings taken over the structure, the adjusted elevation is estimated to be -4.4 ft (-1.34 m) NAVD88. The as-built drawings from 2012 show a final constructed elevation of -5.0 ft (-1.52 m) NAVD88. Since it is unlikely that the elevation has increased since the previous inspection, we believe that there was an error in the elevation reading from the handheld fathometer and that the data is incorrect. The weir section located closest to the south bank of the structure appears to be stable and no obvious settlement was observed since the structure was capped in 2012. Based on staff gauge readings, the crest of the south section was approximately 3.0 ft (0.91 m). The north weir section did seem to settle slightly since it was recapped in 2012. Based on the existing staff gauge, it appears that the elevation of the crest of the north weir section was approximately +2.5 ft (0.76 m). The warning signs on Structure 2 are in good condition and no maintenance will be required at this time. (See Appendix A, Photos 16 through 18).

Structure 4 – Fixed crest rock weir with boat bay

Structure 4 was also capped with riprap in 2012 to bring the crest to its original elevation. At the inspection, Structure 4 was in good condition with no visual signs of settlement or rock displacement. On previous inspections, it was noted that the marsh on the southern tie-in continues to erode and has detached from the rock weir. The southern tie-in has been repaired and the rock dike extended along the shoreline to connect to structure 2 under the 2015 Maintenance Project. It was also noted previously that the warning signs have deteriorated and need replacement. CPRA completed a multi-project sign replacement project in 2017 which included signs along Structure 4 and 4A of the GIWW to Clovelly (BA-02) project. (See Appendix A, Photo 14 and 15)

Structure 7– Fixed crest rock weir w/ boat bay

Structure 7 appeared to be in fair condition with noticeable settlement of the rock riprap material on each side of the boat bay. Based on water elevations from the CRMS station along Superior Canal, we estimated the crest elevation of the rock weir on both sides of the boat bay to be between 1.5 ft (0.46 m) and 1.6 ft (0.49 m). There was no visual damage to the weir or erosion around the embankment tie-ins. Soundings taken at the boat bay indicated a water depth of approximately 6.8 ft (2.07 m), which would correspond to an elevation of -5.2 ft (-1.58 m) NAVD88 after adjustments. The original as-built drawings show the crest elevation at the boat bay was constructed to -4.4 ft (-1.34 m) NAVD88. Settlement since construction of Structure 7 is estimated to be approximately 1.0 ft. We are not recommending maintenance of Structure 7 at this time. All warning and navigational signs and their supports appear to be in good condition. See Appendix A, Photos 5 through 7)

Structure 8– Rock rip-rap weir

Structure 8 is a small rock weir with a boat bay located just north of Structure 7. The existing channel is very narrow and access is limited. From a distance, the structure appears to be in fair condition with minimal settlement of the riprap material and no erosion or washouts around the bank tie-ins. This structure was originally constructed with a steel gate to prevent access into the interior marsh, but this gate was destroyed during Hurricanes Gustav and Ike. The landowner had replaced the steel gate with floating barrels. Currently, the barrels are gone and the structure is open to access., There are no plans for maintenance of the structure or to replace the gate or barrels. (See Appendix A, Photo 8)

Structure 43 – Rock rip-rap channel plug

Structure 43 is not visible from the canal due to vegetation and water hyacinth blocking the structure. During past inspections, it was noted that a small opening had developed on the east side of the structure connecting the interior marsh to the canal. We were unable to locate the opening or see any water flow around the structure. All warning signs and support structures appear to be in good condition, and at this time, there are no recommendations for maintenance. (See Appendix A, Photo 39)

Structure 91 – Rock plug with culvert and flap gate

Overall, Structure 91 rock plug appeared to be in good condition. The rock structure was covered with heavy vegetation and woody debris; however, it appears to be in good condition with no obvious settlement or breaches around the structure. The timber piles, the corrugated metal pipe and flap gate were in fair condition and appeared to be operational. There are no plans for maintenance of Structure 91 at this time. (See Appendix A, Photo 34)

CONSTRUCTION UNIT NO.2

Structure 1 – Fixed crest rock weir w/ barge bay

Overall, structure 1 appeared to be in good condition with no visual signs of settlement or damage of the rock structure or erosion along the bank tie-ins. The four (4) timber pile dolphin structures at the entrance of the barge bay opening were replaced in 2012 and are in good condition. (See Appendix A, Photos 36 through 38)

Structure 4A & 4B – Rock rip-rap channel plug

Structures 4A and 4B were recapped in 2012 to its original design elevation. A rock dike closure was also constructed from structure 4A to structure 4 to close a large opening in the marsh. The rock dike closure was approximately 1,000 linear feet long and was built to a +3.5 elevation. Structure 4A, 4B and the rock dike closure were all in good condition with little or no visual signs of settlement. We did notice erosion on the north side of structure 4B where the marsh has retreated. This is a normal occurrence where a hardened structure abruptly ends. As reported on previous inspections, the warning signs were damaged and deteriorated over time. CPRA replaced all of the signage along Structure 4A and 4B in 2017 under a multi-project maintenance event. (See Appendix A, Photos 9 through 13)

Structure 14A – Fixed crest rock weir with barge bay

Structure 14A was also rehabilitated in 2012. The structure was recapped with a heavier 250# class rock riprap to the original design elevation of -6.5 ft at the barge bay to prevent further scouring of the channel bottom, and +4.0 ft along the first 100 feet of the crest on both sides of the barge bay. Depth soundings were taken along the center of the barge bay which indicated that the water depths were approximately 6.8 ft. Based on this depth, the adjusted bottom sill elevation of the barge bay was approximately -6.2 ft. Based on our observations, the structure appears to be in good condition, as there is no visible settlement of the rock since 2012. The navigation aid structures and warning signs also appear to be in good condition. The south bank tie-in to the shoreline is experiencing slight erosion, but appears to be stable. There are no recommendations for maintenance of structure 14A at this time. (See Appendix A, Photos 1 through 4)

Structure 35 – Variable crest weir, water control structure

Overall, structure 35 has moderate corrosion on the bulkhead cap, handrails and deck. The stop logs, cables, signs and supports appear to be in good condition and operable. At the time of inspection the channel from the weir to the interior marsh was open and there appeared to be adequate flow through the interior marsh and structure. The embankment tie-ins also appear to be

in good condition with no erosion or washouts. We are not recommending any repairs or corrective actions at this time. (See Appendix A, Photos 26 through 29)

Structure 90 – Rock rip-rap channel plug

Structure 90 was difficult to access and view due to heavy vegetation on the structure and in the canal leading to the structure. From what we were able to view, the structure appeared to be in good condition with no obvious settlement or breach around the bank tie-ins. The warning signs and supports were also in good condition. There are no recommendations for maintenance of structure 90 at this time. (See Appendix A, Photo 35)

Lake Rim Restoration

The Lake Rim structure was also refurbished in 2012 and appeared to be in good condition. The existing rock structure was recapped to a crest elevation of +3.5 to +4.0 ft along the north bank of Breton Canal and Bay L'Ours to structure 2. There are no visual signs of settlement or displacement of the rock along the structure and the warning signs are in good condition. There are no recommendations for maintenance at this time. (See Appendix A, Photos 18 through 25)

Earthen bank stabilization

There were five (5) breaches repaired in the 2012 Maintenance Project. Breach 1 was located along the north bank of Breton Canal just southwest of the first location canal from Bay L' Ours and was approximately 20 ft wide. Breach 2 was located along the northeast bank of the second location canal north of Breton Canal and was approximately 10 ft wide. Breach 3 was located on the south bank of the same location canal as breach 2 and was approximately 25 ft wide. Breach 4 was located on the west bank of an oilfield canal that intersects Breton Canal east of structure 1 and was approximately 30 ft wide. Another breach, designated as breach 5, was discovered at the end of a dead end oilfield slip south of breach 4. The breaches were closed by using material from the adjacent canal bottoms to reconstruct the earthen dike. The material was allowed to dry before it was shaped, seeded, and fertilized. All breach repairs appear to be in good condition with no signs of settlement or erosion. We did note a large breach along the north bank of Breton Canal east of breach repair 1. (See Appendix A, Photos 30 through 33)

c. Maintenance Recommendations

Overall, the GIWW to Clovelly Hydrologic Restoration Project (BA-02) was in good condition with no obvious deficiencies. This project has reached its 20-year life. NRCS and CPRA have decided to cease all operations and maintenance activities and submit the project to the CWPPRA Task Force to be closed out.

d. Maintenance History

2012 Maintenance Project: This project was the first major maintenance event since the completion of the original project. Since the 2008 Annual Inspection of the GIWW to Clovelly Hydrologic Restoration (BA-02) project, a number of deficiencies had been documented that required corrective actions and/or refurbishment. In February 2010, CPRA initiated maintenance of the GIWW to Clovelly Hydrologic Restoration - 2012 Maintenance Project by contracting MWH Americas, Inc. of Baton Rouge to perform the design. Prior to beginning the design, John Chance Surveyors, Inc. of Lafayette was contracted to perform the necessary design surveys to supplement the data obtained from the 2008 surveys. The plans and specifications for the project were completed in May 2011 and were reviewed by both CPRA and NRCS. The modification to the overall maintenance permit obtained in 2007 to include the breach closure between structures 4A and 4 was approved and was included in the final bid package. The final bid documents were submitted to the Louisiana Office of State Purchase to be bid. The bid process took place in August 2011 and the maintenance project contract along with the bid alternate was awarded to DQSI, Inc. The construction administration and inspection services were handled by Providence/GSE of Houma, LA. Mobilization of DQSI to the jobsite and work on the breach repairs began in December 2011. Construction of the project was completed in June 2012 and final acceptance was on July 24, 2012. The 2012 Maintenance Project was completed for a total cost of \$3,435,923.58, which includes construction by DQSI, surveys by John Chance, E&D by MWH, and administration and inspection by Providence/GSE. A summary of the work completed in the 2012 Maintenance Project is found below:

- Four (4) timber pile clusters and navigational aids replaced on structure 1
- Three (3) timber pile clusters and navigational aids replaced on structure 14A
- Approximately 10,600 linear feet of the Lake Rim rock dike refurbished
- Approximately 1,000 linear foot rock dike extension created from structure 4 to structure 4A & 4B
- Structure 4A & 4B recapped to original design elevation
- Structure 4 and structure 2 recapped to original design elevation
- Structure 14A barge bay recapped to original design elevation
- Five (5) breach closures along existing oilfield canals in southern section of the project area

2015 Maintenance Project – is the second major maintenance project since the completion of the original project. During the years following the 2012 Maintenance Project, significant erosion of

the marsh shoreline occurred between structures 2 and 4. This area is the only section of marsh shoreline that was not protected by a hardened structure along the shoreline of Bay L' Ours between structure 4A and Breton Canal. Additional funding was secured from the CWPPRA Task Force to increase the O&M budget to accommodate the cost for remedial action in this area. The project consisted of approximately 1,750 linear feet of rock dike along the existing shoreline to close the unprotected area between structures 2 and 4. The contract was awarded to DQSI, LLC of Covington in the amount of 1,457,850 and the project was completed on May 20th, 2017.

III. Operations Activity

In accordance with the operation schedule outlined in the Operations and Maintenance plan and the special conditions of the permit, structure 35 has been operated during the months of April and November of each year since April 3, 2002. This project has reached its 20-year life and NRCS and CPRA have decided to cease all operations and maintenance activities and submit the project to the CWPPRA Task Force to be closed out.

IV. Monitoring Activity

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the BA-02 Monitoring Plan to integrate it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There is one CRMS site located in the project area, CRMS0190. This site was established on November 7, 2011 after construction.

a. Monitoring Goals

Specific objectives of the GIWW to Clovelly Hydrologic Restoration (BA-02) project are (1) to protect and maintain approximately 14,948 acres (6,049 hectares) of intermediate marsh by restoring natural hydrologic conditions that promote greater freshwater retention and utilization, prevent rapid salinity increases, and reduce the rate of tidal exchange; and (2) to reduce shoreline erosion through shoreline stabilization (Lear 2003).

The following goals will contribute to the evaluation of the above objectives:

1. Increase or maintain marsh to open water ratios.
2. Decrease salinity variability in the project area.
3. Decrease the water level variability in the project area.

4. Increase or maintain the relative abundance of intermediate marsh plants.
5. Promote greater freshwater retention and utilization in the project area.
6. Reduce shoreline erosion through shoreline stabilization.
7. Increase or maintain the relative abundance of submerged aquatic vegetation (SAV).

b. Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

Habitat Mapping

To document vegetated and non-vegetated areas and marsh loss rates, color-infrared aerial photography (1:24,000 scale with ground control markers) was obtained by the Wetland and Aquatic Research Center/United States Geological Survey (WARC/USGS) for the project area. For each flight, the photography was geo-rectified, photo-interpreted, mapped, ground-truthed, and analyzed with Geographic Information System (GIS) by WARC personnel using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2012, revised 2014). Photography was obtained prior to construction in November 1993 and in December 1996, and after construction in December 2002. WARC personnel reviewed the current vegetation, water level, and salinity data at the time to assess the photography for revisions and produced updated maps (Appendix B; figures 1-3).

Land-Water

Based on the CRMS-*Wetlands* (Coastwide Reference Monitoring System) review, land-water analyses were performed in place of habitat mapping on photography collected in 2008, 2012, 2016. The 2012 and 2016 analyses were the final effort for this project. Due to a large land-water change between the 2008 and 2012 imagery, CPRA requested joint field investigations with USGS/WARC to verify the imagery. Ground-truthing confirmed the imagery analyses. The result was a multi-temporal analysis of land area change, which updated existing product (B. Couvillion, USGS, pers. Comm.). All habitat maps and land-water maps are located in appendix B of this report.

Water Level

To monitor water level variability, seven (7) continuous recorder stations were established inside the project area; however, two (2) stations (BA02-58 and BA02-59) were discontinued due to severe scouring around the instruments. Discrete water depths were measured monthly at 25

stations inside the project area (Appendix C; figure 1) using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2014). Staff gauges located adjacent to the continuous recorders were surveyed to the North American Vertical Datum of 1988 (NAVD88) in order to tie recorder water levels to the Louisiana Coastal Zone GPS network. Marsh elevation was surveyed and used in conjunction with continuous recorders to determine duration and frequency of flooding.

Based on the CRMS-*Wetlands* review, discrete water level readings were discontinued in January 2004, and continuous water level readings from stations BA02-53, BA02-54, and BA02-55 were discontinued in March 2004. As a result, only two of the original project-specific continuous recorder stations remained active throughout the project life. Water level data was also collected at CRMS0190.

Salinity

To monitor salinity variability, seven (7) continuous recorder stations were located inside the project area; however, two (2) stations (station BA02-58 and BA02-59) were discontinued due to severe scouring around the instruments. Discrete salinity was measured monthly at 25 stations inside the project area (Appendix C; figure 1) using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2014).

Based on the CRMS-*Wetlands* review, discrete salinity readings were discontinued at the project stations in January 2004, and continuous salinity readings from stations BA02-53, BA02-54, and BA02-55 were discontinued in March 2004. As a result, only two of the original project-specific continuous recorders remained active throughout the project life.

Vegetation

Species composition and relative abundance were evaluated inside the project area using a modification of the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974). Twenty-five (25) plots were established and sampled in the project area during the 1996 sampling event. Eight (8) of these plots in the northern portion of the project area were dropped from monitoring in late spring 1997 due to land rights issues. Vegetation species composition and relative abundance were documented once prior to construction in 1996, once in 1999 after Construction Unit No. 1 was completed, and five times after Construction Unit No. 2 was completed in 2000, 2002, 2005, 2008, 2012 and 2016. Species composition and relative abundance were also evaluated inside the BA-02 project area CRMS site (CRMS0190). The CRMS site (1 km²) contained a 200 m² data collection area, which in turn had ten (10) vegetation data collection stations located along a single

transect. Vegetation species composition and relative abundance were evaluated annually after construction from 2006 through 2016.

Soil Samples

To evaluate effects of freshwater retention and saltwater intrusion, project-specific soil samples were taken to determine percent organic matter and bulk density using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2014). Twenty-five (25) plots were established and sampled in the project area during the 1996 sampling event. Eight (8) of these plots in the northern portion of the project were dropped from monitoring in late spring 1997 due to land rights issues. Soil samples from the remaining seventeen (17) project area plots were evaluated once prior to construction in 1996, once in 1999 after Construction Unit No. 1 was completed, and six times after Construction Unit No. 2 was completed (2000, 2002, 2005, 2008, 2012, and 2016). Soil cores were taken at the project CRMS site (CRMS0190) at the time of its establishment in June 2006.

Shoreline Change

To evaluate marsh edge movement along the shoreline protection structures placed in Bay L'Ours and along the oil and gas access canal at the southern border of the project area, controlled sub-meter accurate Differential Global Positioning System (DGPS) equipment was used by CPRA personnel to document marsh edge position using techniques described in Steyer et al. (1995, revised 2000) and Folse et al. (2014). This equipment was used to acquire the coordinates for each shoreline point within 21 randomly selected 300 ft (91.4 m) shoreline segments. DGPS measurements were taken pre-construction in 1993 and 1998, and post-construction in 2000, 2003, 2005, 2008, 2012, and 2016. The 2005, 2008, and 2012 surveys were conducted by Shaw Coastal, Inc., also using sub-meter accurate equipment described in the preliminary monitoring results and discussions section of this report for shoreline change.

Submerged Aquatic Vegetation (SAV)

The frequency of occurrence of SAV was analyzed for the project area. Ten (10) ponds inside the project area and five (5) ponds inside the reference area were sampled once in the fall of 1996 (November) pre-construction. Three (3) ponds in the northern portion of the project area as well as the five ponds in the reference area were dropped from monitoring in the late spring 1997 due to land rights issues. Data collection on the remaining seven (7) ponds occurred four times after Construction Unit No. 1 was completed; during spring 1999, fall 1999, spring 2000, and during fall 2000. Post-construction data collection occurred during fall 2002 and fall 2005. Based upon the CRMS-Wetlands review, all SAV data collection was discontinued after 2005 (see Appendix C; figure 2).

CRMS-Wetlands

In 2003, the CWPPRA Task Force adopted the CRMS-*Wetlands* program to evaluate the effectiveness of each constructed restoration project. The CRMS-*Wetlands* program provides a network or “pool” of reference sites that can be used to not only evaluate the effectiveness of individual projects but also hydrologic basins and entire coastal ecosystems. Each 1 km² CRMS-*Wetlands* site is monitored consistently according to a “Standard Operating Procedures” document with the following parameters collected at each site: hourly hydrographic (includes salinity, water level, and water temperature), monthly soil porewater salinity, semi-annual surface elevation and sediment accretion (for non-floating sites), annual emergent vegetation, land:water ratio estimated from aerial photography taken every three to four years, and soil properties collected once at each CRMS site.

CRMS-*Wetlands* is currently in the operational stage (i.e., land rights are secured, site characterizations are complete, and site construction is complete) and all sites are fully operational. Data collection continues at 390 sites and data will be used to help support project-specific monitoring. The GIWW to Clovelly Hydrologic Restoration (BA-02) project has one CRMS-*Wetlands* monitoring site within its project boundary (CRMS0190). In this report the available data from CRMS0190 as well as CRMS-*Wetlands* sites outside the project boundary will be used as supporting or contextual information for the BA-02 project. The trends developed from the available data collected throughout the CRMS-*Wetlands* network now make it possible to report vegetative and hydrologic indices for this project on a site, basin, and coastwide scale.

b. Monitoring Results and Discussion

Habitat Mapping

Data Analysis Methods for Habitat Analysis:

USGS/WARC personnel completed scanning, georectification, and the production of habitat analysis maps for the aerial photography obtained prior to construction in November 1993 and in December 1996, and post-construction in December 2002. In 2004 upon the request of CPRA personnel, WARC re-examined the photography from all three flights as well as the most recent vegetation and salinity data available at the time. Revisions were made to the habitat classification data and updated maps were completed in March 2005.

Habitat Mapping Results and Discussions

When habitat classes are grouped, open water and mudflats excluded, land acreage in the project area increased by 28 acres (11.3 hectares) (table 1). Between 1993 and 2002, habitat classifications shifted resulting in a project area gain of 31 acres (12.5 hectares) of marsh habitat and 186 acres (75.2 hectares) of wetland forest, and a loss of 112 acres (45.3 hectares) of wetland scrub/shrub and 10 acres (4.04 hectares) of upland forested habitat. By 2002, the project area was comprised of approximately 70% intermediate marsh habitat, approximately 6% fresh marsh, approximately 19% open water, and the remaining 5% of land was a mixture of habitat types (Appendix B, figures 1-3).

When all habitat classes are grouped, open water and mudflats excluded, land acreage in the reference area increased by 53 acres (21.4 hectares) (table 1). Between 1993 and 2002, habitat classifications shifted resulting in a loss of all 628 acres (254.1 hectares) of fresh marsh and a gain of 548 acres (221 hectares) of intermediate marsh, as well as approximately 9 acres (3.6) of wetland scrub/shrub. By 2002, the reference area was comprised of approximately 67% intermediate marsh, approximately 27% open water, and the remaining 6% of land was a mixture of habitat types (Appendix B, figures 1-3).

Table 1. BA-02 project and reference habitat class acreages and percentages.

Habitat Class	1993				2002			
	Project Acres	Percent	Reference Acres	Percent	Project Acres	Percent	Reference Acres	Percent
Intermediate Marsh	10717	72.2	2122	53.2	10463	70.5	2668	66.9
Fresh Marsh	626	4.2	628	15.75	849	5.72	0	0
Open water	2846	19.17	1014	25.43	2818	18.98	1067	26.76
Mudflat	1	<1	3	<1	2	<1	4	<1
Rocky Shore	1	<1	0	0	4	<1	0	0
Upland Forested	146	<1	68	1.7	136	<1	63	<1
Upland Scrub-shrub	7	<1	1	<1	1	<1	1	<1
Upland Range	8	<1	0	<1	6	<1	0	<1
Upland Urban	6	<1	2	<1	5	<1	2	<1
Wetland Scrub-Shrub	289	1.94	77	1.93	177	1.19	86	2.15
Wetland Forested	193	1.3	72	1.8	379	2.55	96	2.4

Land Water

Data Analysis Methods for Land Water:

USGS/WARC personnel completed scanning, georectification, and the production of land-water maps for the aerial photography obtained post-construction in 2005, 2008, 2012, and 2016. In addition to these maps, land-water acreages were calculated from the habitat analysis maps created by USGS/WARC in 1993, 1996, and 2002. Statistics for intermediate and fresh water bodies, with mudflats included, were grouped together to get the open water component, while all other habitat types were grouped together for the land component. These acreages were converted into percentages, then rates were calculated for various time periods. All habitat analysis maps and land-water maps are located in appendix B of this report.

CRMS-*Wetlands* site data were also examined in order to determine the percent land area change per year for the project area site and the six reference sites. Data for these sites were based upon regular Landsat imagery analyses from 1984-2016 (CPRA May, 2018).

Land Water Results and Discussions

Based upon the USGS/WARC revised analyses, the BA-02 project area experienced land gain of 0.02%/yr during pre-construction (1993-2002), and land loss of -0.17%/yr during post-construction (2002-2016). The overall rate was -0.09%/yr (1993-2016) (figure 3). The reference area lost -0.13%/yr during pre-construction, gained 0.02%/yr during post-construction, and experienced an overall loss of -0.04 %/yr. The greatest land-water changes occurred from 2002 through 2005, and from 2008 through 2016. Land loss was most likely due to the effects from large and powerful tropical weather systems. Interestingly, land loss in the project area between 2005 and 2008 was noticeably less than between 2002 and 2005, while it changed very little in the reference area.

The most notable changes occurred inside both the project and reference areas between 2008 and 2012, and again from 2012 through 2016. Both areas experienced a large shift from open water to land. USGS and CPRA personnel conducted field investigations in 2016 to see if these changes were real. The investigations confirmed that the changes identified through photo-interpretation of the 2012 and 2016 imagery were accurate. The 2012 imagery was the first year without recent storm impacts from major storms. It is possible that between 2012 and 2016 land loss rates were reduced or some net stability in the loss rate was achieved due to a pause in major tropical weather system activity (B. Couvillion, USGS, per. Comm.). Additionally, during field investigations it was observed that these land changes may be due to transient floating vegetation mats expanding and attaching to existing pond edges and growing into the substrate.

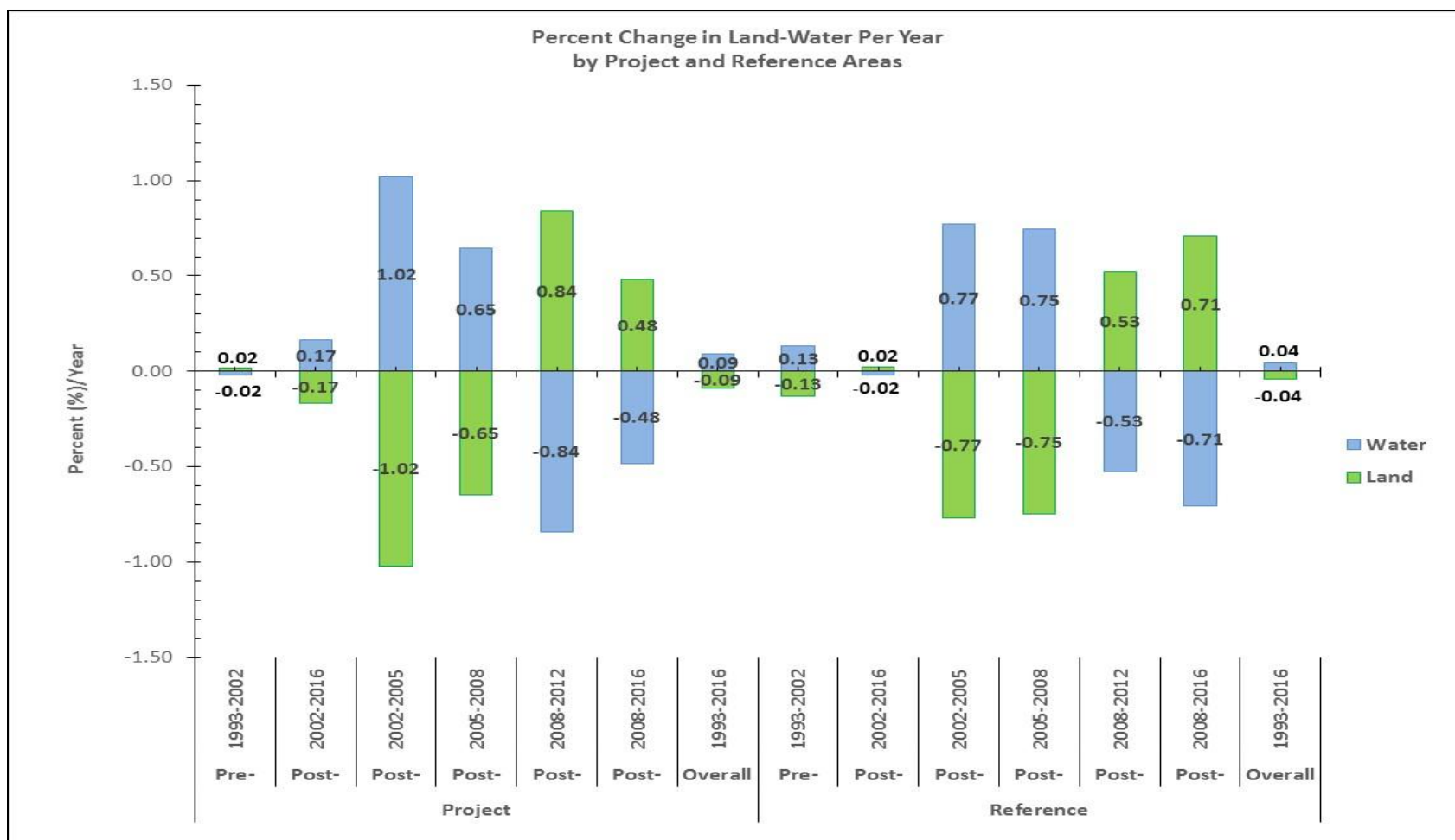


Figure 3. Percent change in land-water for pre-construction, post-construction, and overall for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Investigators found that species not typical of “floating” marsh such as *Salix nigra* Marshall saplings, had established themselves on the new substrate. The substrate was firm enough to support the weight of an individual walking upon it. As a result, observers deemed that the most appropriate categorization for these areas as land. Even greater rates of land change occurred in a similar fashion inside of the reference area between 2008 and 2016.

CRMS-*Wetlands* site data analysis indicated that the project site lost land acreage at a rate of -0.04%/yr between 1993 and 2016 (figure 4). The rate was the same for pre- and post-construction. The reference CRMS-*Wetlands* sites experienced land loss at an overall rate of -0.52 %/yr. The loss rate was highest during pre-construction (1993 and 2000), then tapered off during post-construction (2000 through 2016). Based upon this analysis, the project area site still lost land, but it was at a much reduced rate when compared to the reference sites. Loss rates at the project site remained stable while reference site losses fluctuated.

Water Level

Project-specific and project CRMS-*Wetlands* continuous recorder stations where hourly water level data have been collected are found in table 2 (figure 5). CRMS-*Wetlands* recorders used as reference sites are shown in figure 6. One of the continuous recorder stations (station BA02-59) was gone, presumed to be scoured out, during pre-construction; therefore, there are no comparative post-construction data available for this station. CRMS0190-W01 was a marsh well station replaced with CRMS0190-H01, an open water recorder, at the request of CPRA. The marsh well recorder was replaced because salinity data collected from the marsh well station when water levels fell below the marsh surface represented porewater readings which were not comparable to surface water readings from open water recorders in the project area. Reference areas selected to the north and northeast of the project boundary were eliminated due to land rights issues during late spring 1997. Changes in water level values were measured on a continuous hourly basis for this project utilizing open water continuous recorders deployed at stations inside of the project boundary and constructed according to CPRA standard operation procedures (Folse et al. 2012, revised 2014).

In addition to the project specific open water recorders, one CRMS-*Wetlands* site (CRMS0190) with a marsh well continuous recorder setup as well as a floating marsh mat continuous recorder setup was constructed inside the project area according to CPRA standard operation procedures (Folse et al. 2012, 2014). Data from the marsh well recorder was unreliable and not comparable to the open water recorders so it was not used in the analysis for this report. The marsh well station

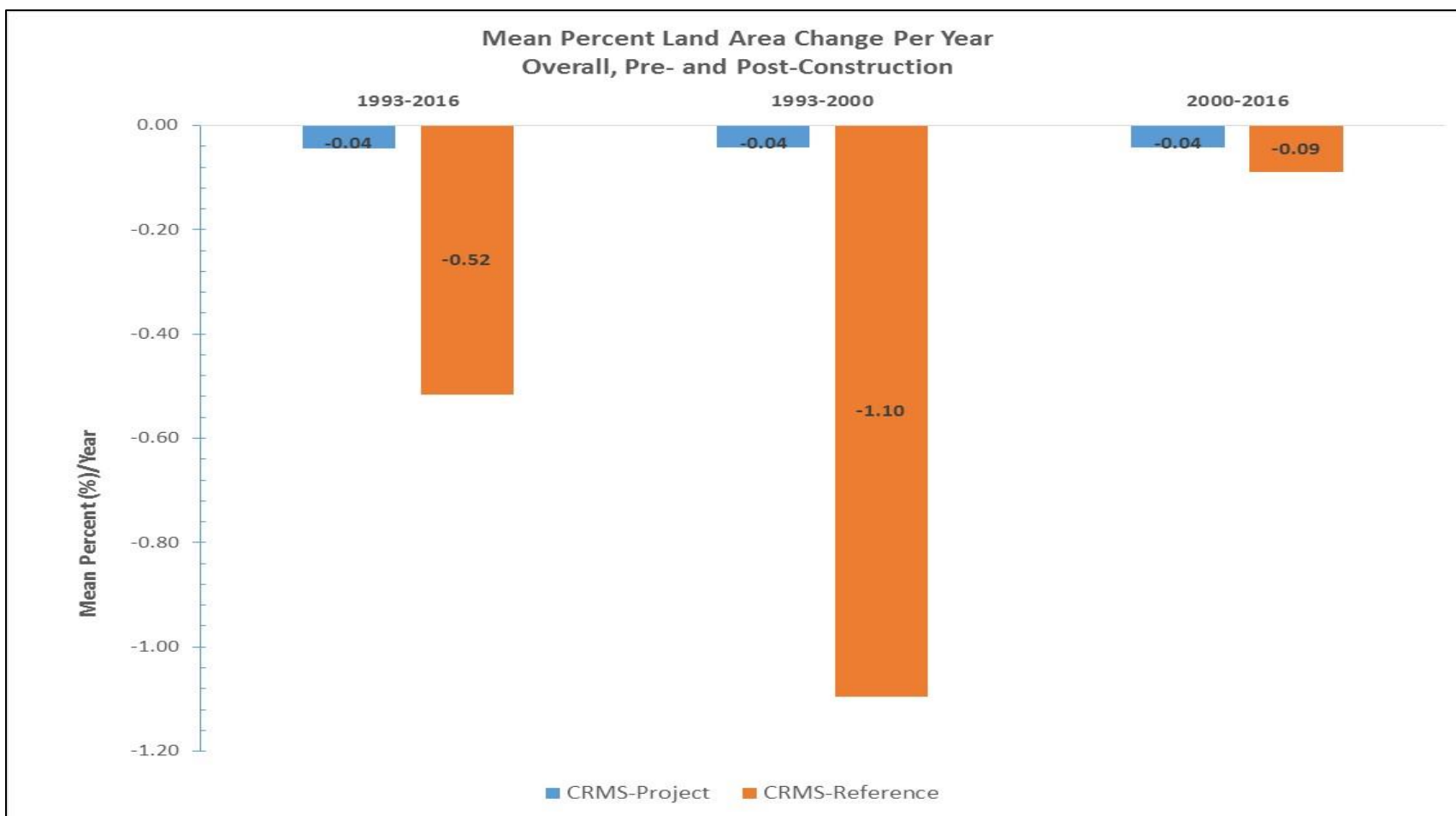


Figure 4. Mean percent land area change rates at CRMS-*Wetlands* project and reference sites.

was inactivated and replaced by an open-water recorder in February 2010 in order to acquire more comparable data.

Table 2. Project-specific and project area CRMS-*Wetlands* continuous recorder stations and their data collection durations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Station	Data Collection Period
BA02-53	07/01/1997 - 03/23/2004
BA02-54	07/02/1997 - 03/23/2004
BA02-55	06/24/1997 - 03/23/2004
BA02-56	06/24/1997 - 12/04/2017
BA02-57	07/01/1997 - 12/04/2017
BA02-58	07/01/1997 - 07/24/2002
BA02-59	07/01/1997 - 10/12/1998
CRMS0190-W01	06/13/2006 - 09/30/2010
CRMS0190-M01	06/13/2006 - Present
CRMS0190-H01	02/26/2010 - Present

*Continuous recorder stations BA02-58 and BA02-59 were lost due to scouring of the channel bottoms where the stations were located.

Data Analysis Methods for Water Level:

Since the 2007 report, three of the five project continuous recorder stations have been inactivated due to the CRMS-*Wetlands* review. Due to these factors, data presented in this report is not as extensive as the 2007 OM&M Report (Lear et al. 2007).

Data collected from the two remaining project-specific continuous recorders (BA02-56 and BA02-57), the project CRMS-*Wetlands* recorder (CRMS0190-H01), and the CRMS-*Wetlands* reference recorders (CRMS0220-H01, CRMS0248-H01, CRMS0253-H01, CRMS0261-H01, CRMS4218-H01, and CRMS6303-H01) are presented in this report. Not all of the CRMS-*Wetlands* stations were established at the same time therefore only concurrent data was used for analyses (02/26/2010 – 10/11/2017). Quality Assurance/Quality Control (QA/QC) was completed on all continuous hydrographic data. The data was transformed to GEOID99 for all CRMS-*Wetlands* stations (October 1, 2013 going forward) prior to analysis.

In this report water level data from all of the aforementioned continuous recorders were analyzed using multiple approaches in JMP®, version 13. A pairwise Tukey-Kramer comparison of weekly means was also performed in JMP®. For CRMS-*Wetlands* stations, the Hydrologic Index (HI) scores were determined and presented on project, basin, and coast wide scales utilizing the CRMS data visualization tool on the CPRA website (CPRA Jan, 2018). The hourly readings were used

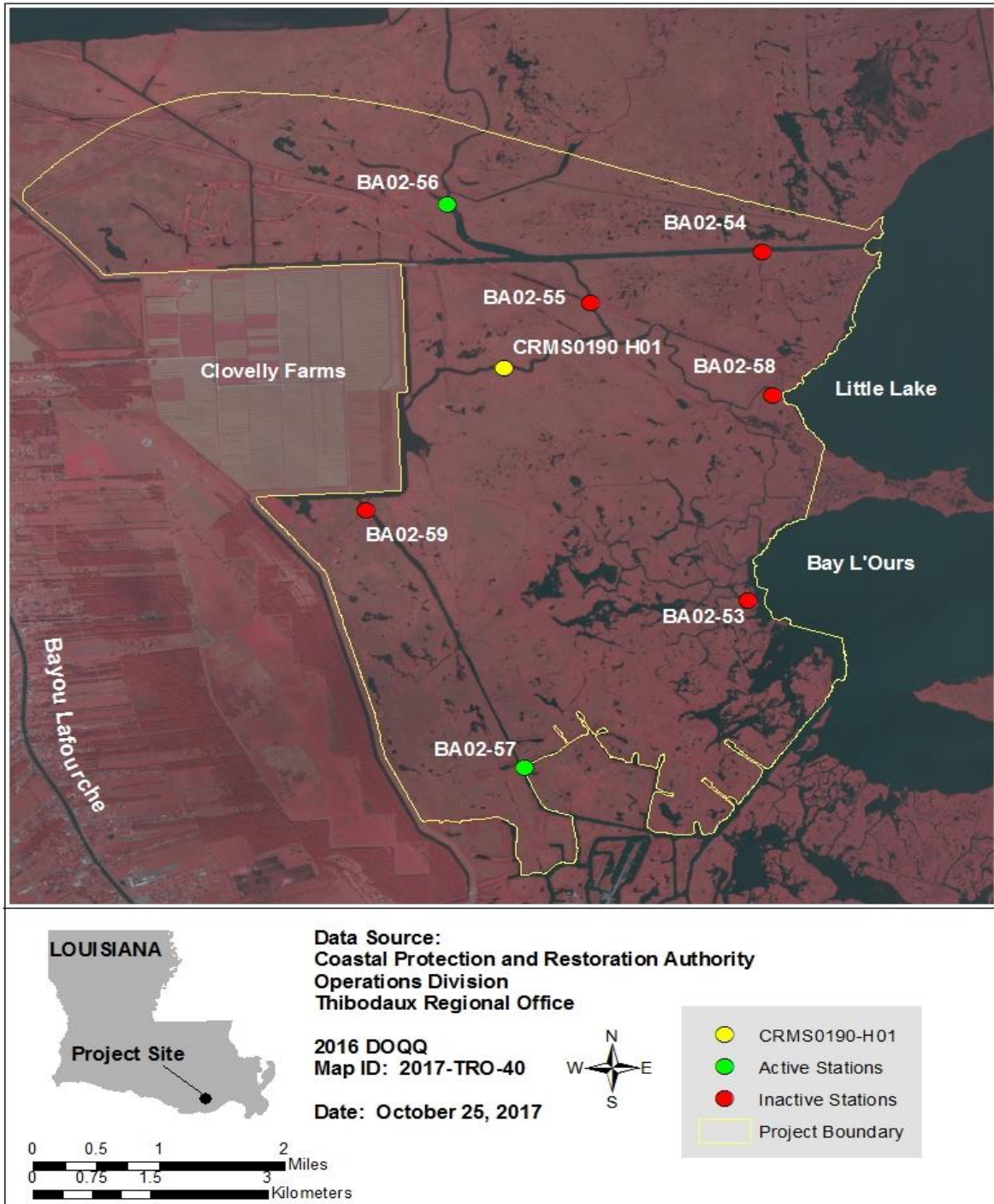
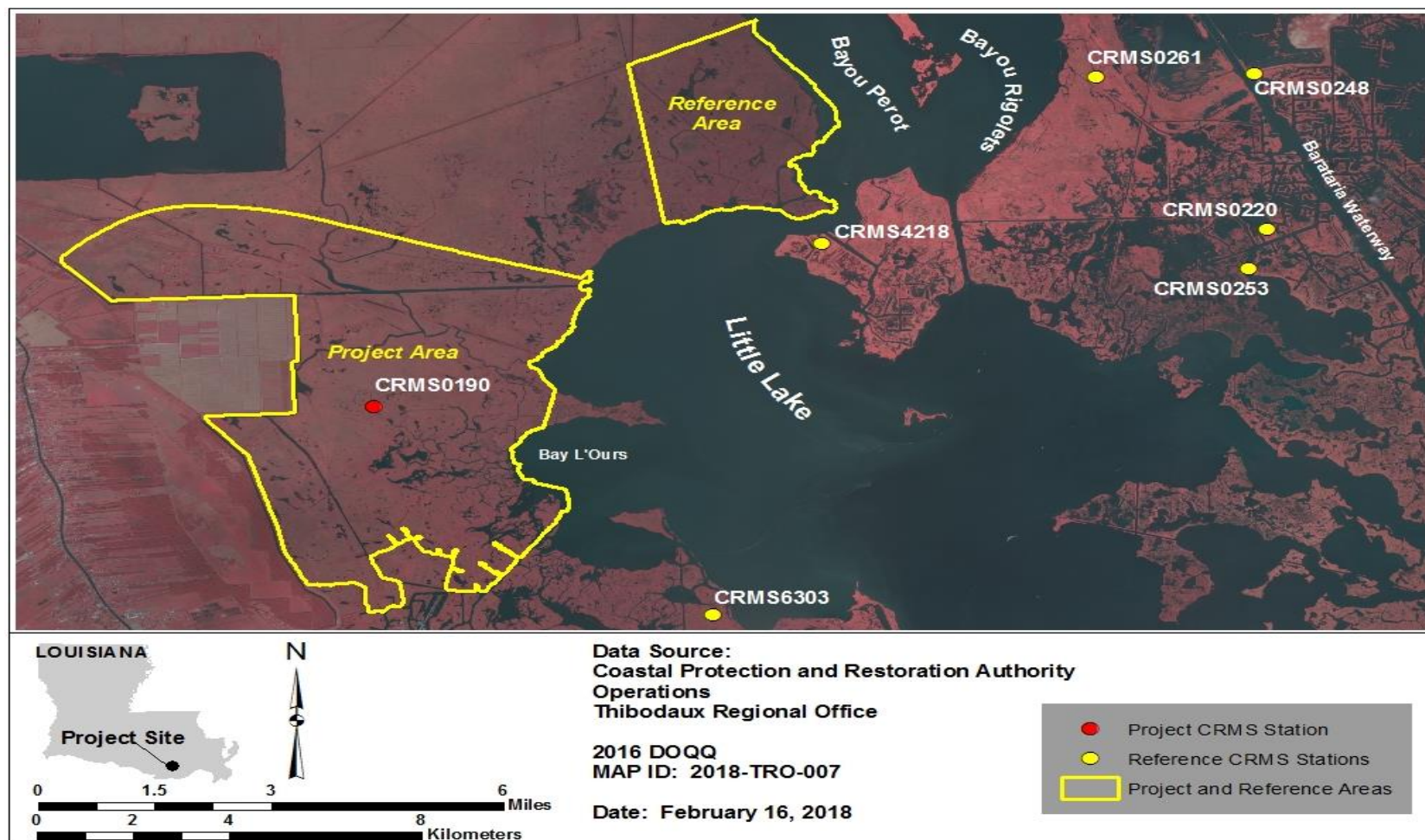


Figure 5. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project continuous recorder surface water station locations and CRMS0190 continuous recorder surface water station.



to calculate both the overall water elevations and the yearly mean, minimum, and maximum water elevations. Ranges were calculated as well.

The HI score was developed by CRMS analytical teams based upon parameters collected at CRMS sites from 2006 through 2009 across the Louisiana coast from which they developed a baseline distribution. The index was designed to help better understand the condition of coastal wetlands at various time and spatial scales (Snedden et al. 2012) and it has been refined through the years. The index takes all the hourly salinity and water level observations at a given CRMS site and provides an idea as to how conducive the hydrology is for emergent marsh vegetation productivity for a given marsh type. A site is classified as good (green) if it's score is greater than 75% of all CRMS site scores calculated during this baseline period, fair (yellow) if it falls within the 25% to 75% range, and poor (red) if it is less than 25%. For this report, the CRMS website data viewer was used to determine the the HI scores, which are calculated by year, and require greater than 70% data completeness for a particular year in order to obtain a score.

Water Level Results and Discussions

Project Specific Stations:

A Tukey-Kramer test was performed in JMP® on all continuous recorder stations to determine differences in the weekly mean water levels for project and reference pairwise comparisons (table 3). The analysis was based upon a period of record where only concurrent data occurred at all recorder stations (02/26/2010 – 10/11/2017). Continuous recorder stations inside the project boundary (BA02-56, BA02-57, and CRMS0190-H01) were grouped separately from the constant recorder stations outside the project boundary (CRMS0220-H01, CRMS0248-H01, CRMS0253-H01, CRMS0261-H01, and CRMS4218-H01). Based upon this analysis, mean weekly water levels between the project and reference areas were not significantly different ($P>0.05$).

Table 3. Connecting letters report from Tukey-Kramer pairwise test of differences, for all project and reference continuous recorder stations. Analysis is based upon weekly mean water levels (NAVD 88) in feet (JMP®, version 13.0).

Connecting Letters Report		
Level		Mean
Reference	A	1.1903758
Project	A	1.1321301
Levels not connected by same letter are significantly different.		

Analysis of all concurrent hourly water level data indicates that the northernmost project specific station (BA02-56) had the smallest range and the lowest mean water levels (table 4). Given that

the average marsh elevation in the vicinity of this station was 1.16 ft (0.35 m) NAVD 88, with mean water levels at 1.02 ft (NAVD 88) flooding was not continuous. Water levels from the southernmost project station (BA02-57) had the widest range and the highest mean water levels than the other two project stations (BA02-56 and CRMS0190-H01). The average marsh elevation in the vicinity of this station was 0.83 ft (0.25 m) NAVD 88. With the mean water levels around 1.26 ft (0.38 m), the marshes may have been frequently flooded. This is likely a result of its location, where it is more tidally influenced. CRMS0190-H01, which is more centrally located in the project area, experienced water elevations which ranged between those of the two project-specific stations (BA02-56 and BA02-57). Since the marsh in the vicinity of CRMS0190-H01 is floating, there is no measurable average marsh elevation here. The mean water levels for CRMS reference stations outside of the project boundary (table 4) were similar to the project stations however, the ranges and maximums appear to have been greater for several of them. This is likely due to their proximity to the Barataria Waterway (CRMS0220-H01, CRMS0248-H01, CRMS0253-H01, and CRMS0261-H01). CRMS6303-H01 is the southernmost station and experiences greater tidal influence. Finally, the overall water level range for the project area stations was 0.81 feet less than the CRMS-*Wetlands* reference stations.

CRMS4218-H01 had the second lowest range of water levels and is located in the same latitude as project station BA02-56. Though still tidally influenced, its water levels were also affected by freshwater flow from Bayou Rigolets and Bayou Perot to the north.

Table 4. Summary of water levels for continuous hydrographic stations inside and outside the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project. For location maps, see figures 5 and 6.

*Adjusted Water Level to Datum (ft) NAVD 88				
Project Stations				
	Mean	Minimum	Maximum	Range
BA02-56	1.02	-0.72	3.92	4.64
BA02-57	1.26	-0.86	5.95	6.81
CRMS0190-H01	1.23	-0.86	5.89	6.75
Overall	1.17	-0.86	5.95	6.81
CRMS Reference Stations				
CRMS0220-H01	1.16	-0.22	6.84	7.06
CRMS0248-H01	1.28	-0.29	6.38	6.67
CRMS0253-H01	1.14	-0.06	6.87	6.93
CRMS0261-H01	1.27	-0.49	5.87	6.36
CRMS4218-H01	1.23	0.19	6.02	5.83
CRMS6303-H01	1.30	-0.75	6.08	6.83
Overall	1.23	-0.75	6.87	7.62

*Note: Calculations are based upon all available concurrent hourly readings (02/26/2010 – 10/11/2017).

Yearly mean water levels are presented in figure 7 for all continuous recorder stations inside and outside the project area. Again, the continuous recorder stations inside the project boundary (BA02-56, BA02-57, and CRMS0190-H01) were grouped separately from the constant recorder stations outside the project boundary (CRMS0220-H01, CRMS0248-H01, CRMS0253-H01, CRMS0261-H01, and CRMS4218-H01). Calculations were made only for the date range where all recorder stations had simultaneous data collection periods (February 26, 2010 through October 11, 2017) in JMP®, version 13. Graphs were produced in Microsoft Excel® 2010. The project area station water levels had a similar pattern from year to year as those outside the project boundary.

CRMS Results:

The HI score is important because it helps to assess the relationship of salinity and inundation to the vegetation productivity at a site. An examination of CRMS0190 relative to all other CRMS-*Wetlands* sites with the same marsh type (intermediate) illustrates the hydrologic condition of the marsh for years 2011 through 2016 (figure 8). Five of the six years had HI scores much higher than the comparative intermediate marsh sites. There was a decrease in the score in 2016, placing it slightly lower than the rest however, it was still above 75.

A comparison of CRMS0190 to all other CRMS-*Wetlands* sites within the same basin (Barataria), and of the same marsh type is presented in figure 9 for years 2011 through 2016. The HI scores were all higher than or equal to the comparative project and reference sites, with the exception of year 2016. In 2016 the HI score fell below the project sites but was higher than the reference sites. All of the CRMS0190 scores were in the fair and good categories (yellow and green).

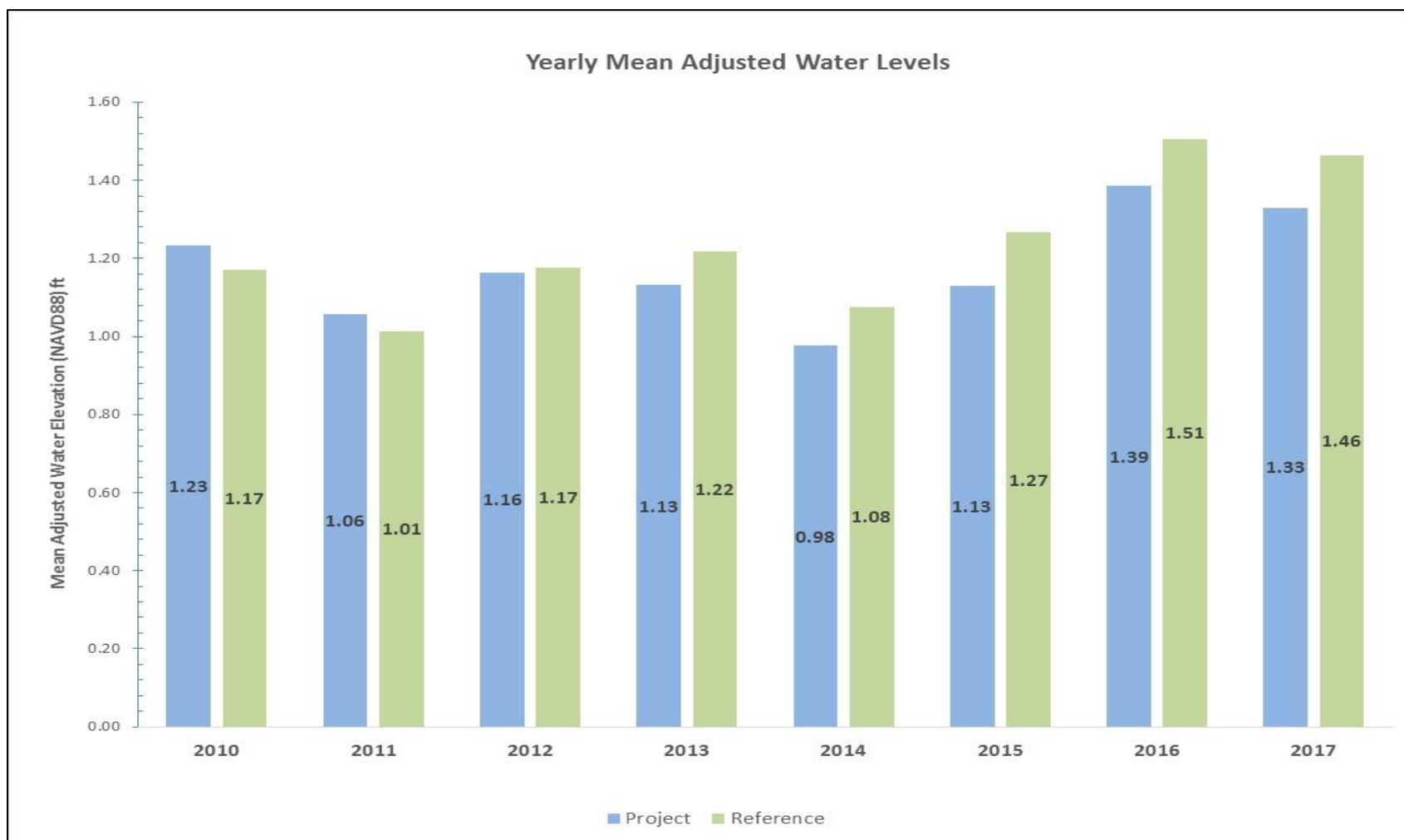


Figure 7. Yearly mean water levels for all open water continuous recorder stations inside and outside of the BA-02 project area.

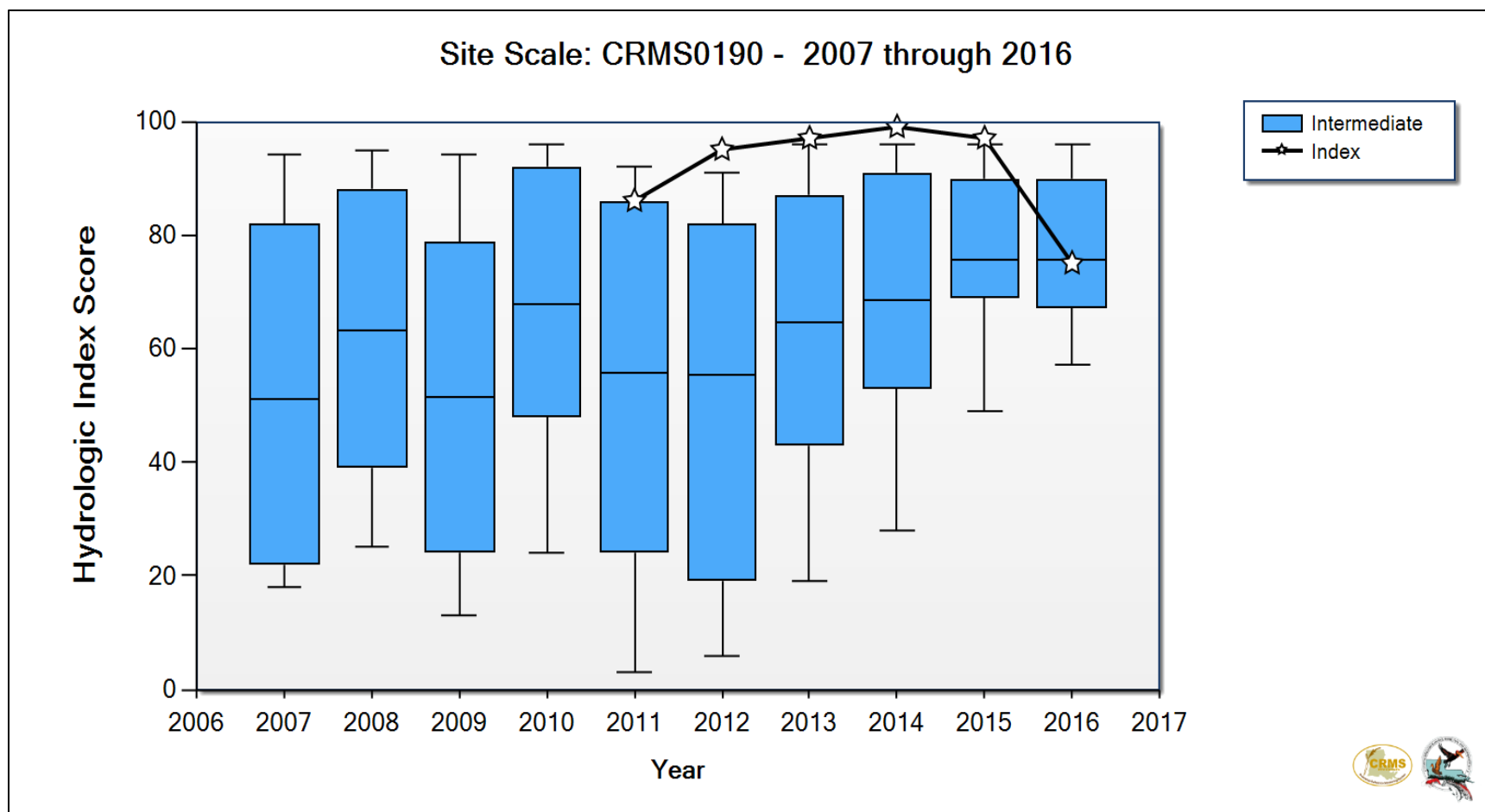


Figure 8. Time series chart of HI scores for CRMS0190 for years 2011 through 2016. HI Scores are represented along the trendline relative to the box plot of scores for all CRMS-Wetlands sites within the same marsh type (intermediate) for each year.

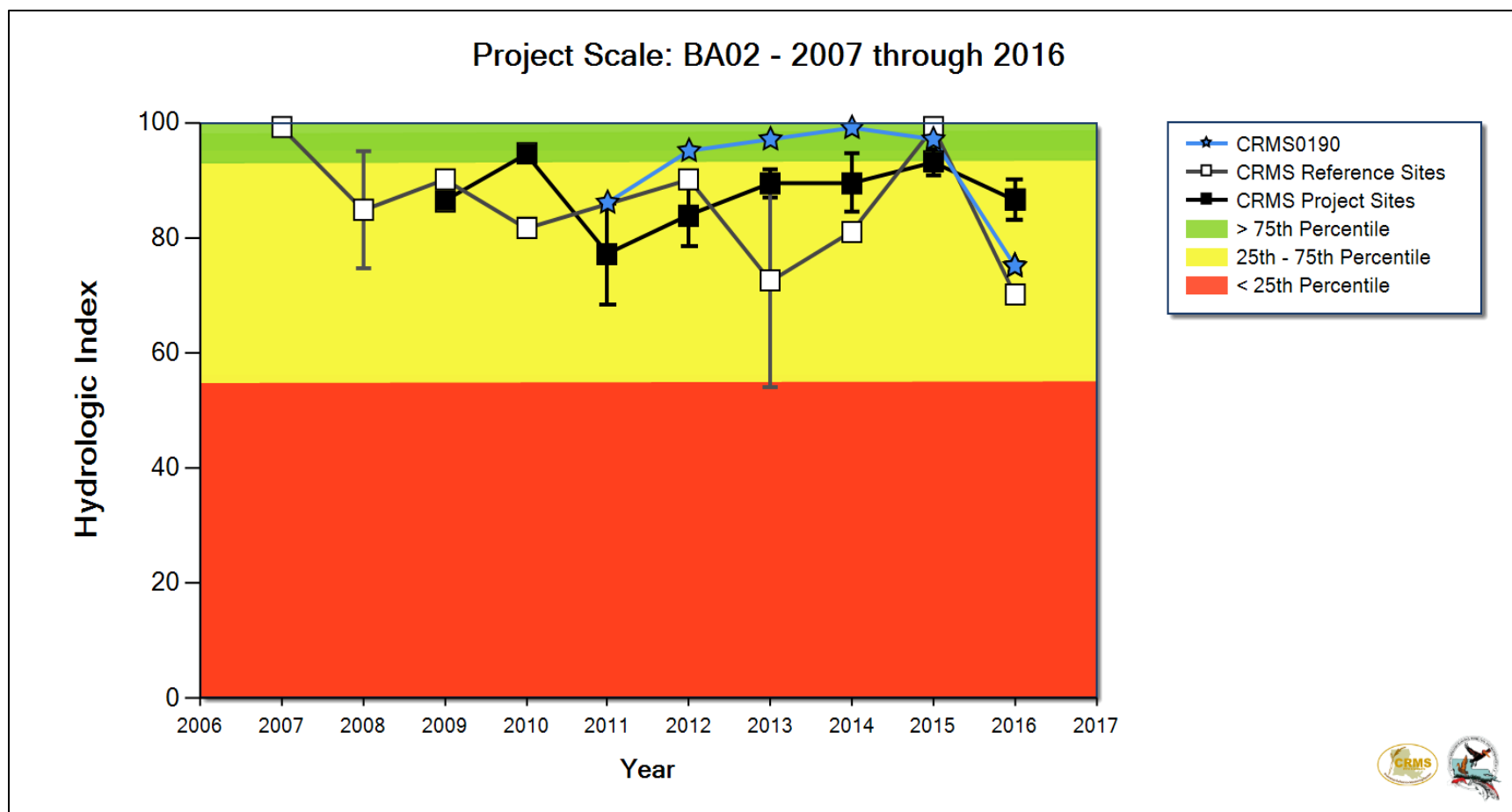


Figure 9. Hydrologic index (HI) scores comparing the CRMS0190 site to other CRMS-Wetlands intermediate marsh sites in the Barataria Basin over time. Note that the HI score for 2010 reference sites was not calculated because the data completeness did not exceed the 70% threshold.

Salinity

A location map of the project and reference discrete salinity stations for the BA-02 project is located in appendix C, figure 1.

The same continuous recorder equipment and stations used to collect water level data were used to collect continuous salinity data inside the project area (table 2; figure 5). In addition, CRMS-*Wetlands* project and reference stations are indicated in figure 6.

Data Analysis Methods for Salinity:

Analysis was performed on discrete salinity data collected from January 1993 through January 2004. Discrete salinity data collection was discontinued in January 2004 due to recommendations based upon the CRMS-*Wetlands* project review. All field data were entered to an electronic format where CPRA/Operations personnel followed quality assurance/quality control (QA/QC) procedures prior to data analysis as stated in Folse et al. (2012, revised 2014). The graphic for discrete salinity was produced in Microsoft Excel® 2010.

Adjusted salinity data for CRMS0190 continuous marsh well and marsh mat recorders (CRMS0190-W01 and CRMS0190-M01) were not included because the data was not comparable to that of the project-specific open water continuous recorders (BA02-56 and BA02-57), as well as CRMS0190-H01. Marsh well and marsh mat recorder sensors record data from water which has been semi-confined to interstitial spaces within the marsh substrate, versus water in free-flowing open water bodies. As a result, the salinity gradient differs between the two water sources. Data analysis methods for salinity in this report were conducted in the same manner as that used for water level utilizing JMP®, version 13.0.

Salinity Results and Discussions

Project Specific Data:

Discrete salinity data for pre-construction and post-construction are graphed in figure 10. The graphic depicts the mean bottom salinity readings for each time period. Of the fifty-two (52) discrete stations originally established, twenty-six (26) of them had data for pre-construction and post-construction time periods. Three of the stations were reference stations and twenty-three (23) were project stations. Reference stations were located immediately outside of weirs on the western rim of Little Lake. The mean discrete salinities for the project stations were lower than those of the reference stations during pre-construction and post-construction.

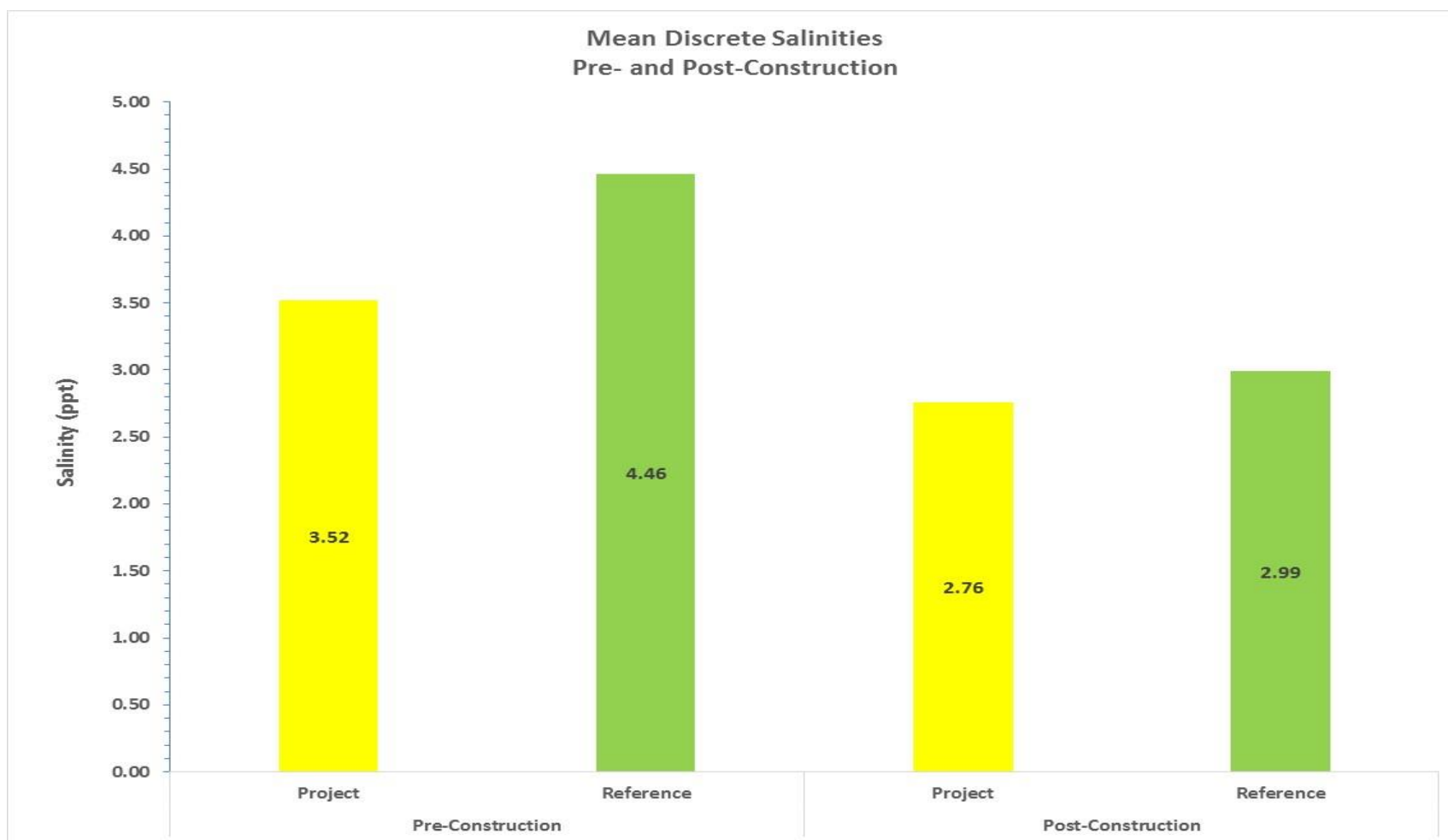


Figure 10. Mean discrete salinities for project and reference stations for pre-construction and post-construction at the BA-02 project.

A Tukey-Kramer test was performed in JMP® on all continuous recorder stations to determine differences in the weekly mean salinities for project and reference pairwise comparisons (table 5). The analysis was based upon a period of record where only concurrent data occurred at all recorder stations (02/26/2010 – 10/11/2017). Continuous recorder stations inside the project boundary (BA02-56, BA02-57, and CRMS0190-H01) were grouped separately from the constant recorder stations outside the project boundary (CRMS0220-H01, CRMS0248-H01, CRMS0253-H01, CRMS0261-H01, and CRMS4218-H01). Project area stations had the lowest weekly mean salinities which were significantly different ($P < 0.05$) than those of the reference recorder stations.

Table 5. Connecting letters report from Tukey-Kramer pairwise test of differences for all project and reference continuous recorder stations. Analysis is based upon weekly mean water levels (NAVD 88) in feet (JMP®, version 13.0).

Connecting Letters Report		
Level		Mean
Reference	A	3.3771885
Project	B	1.3631679
Levels not connected by same letter are significantly different.		

Analysis of concurrent hourly adjusted salinity data indicates that all three continuous recorders inside of the project area had mean salinities within the normal range for a healthy intermediate marsh community (table 6). The southernmost station (BA02-57) had a higher mean adjusted salinity than BA02-56 in the north of the project and CRMS0190 in the center of the project. This is due to the greater tidal influences in the southern reaches of the project.

All of the CRMS-*Wetlands* reference recorders had higher mean salinities than the project area recorders and all of them had higher ranges than the project stations. As with the water levels, the salinities were impacted by the proximity of the stations and their spatial relationships to certain water bodies. The four reference stations closest to the Barataria Waterway and across Little Lake from the BA-02 project area had the highest mean, maximum, and range of salinities (CRMS0220-H01, CRMS0248-H01, CRMS0253-H01, and CRMS0261-H01). The southernmost reference station (CRMS6303-H01), which is on the same side of the lake as the BA-02 project area, had a higher weekly mean and range of salinity, likely due to greater tidal influence.

The weekly mean salinities for CRMS4218-H01 and CRMS0261-H01 were more comparable to the project recorders. CRMS4218-H01 had the largest mean salinity range of all the recorder stations. The proximity of these two stations to Bayou Perot and Bayou Rigolets, which receive

Table 6. Summary of salinities for continuous hydrographic stations inside and outside the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project.

*Adjusted Salinity (ppt)				
Project Stations				
Project Stations	Mean	Minimum	Maximum	Range
BA02-56	1.06	0.14	13.27	13.13
BA02-57	1.74	0.23	10.69	10.46
CRMS0190-H01	1.09	0.09	7.27	7.18
Overall	1.30	0.09	13.27	13.18
CRMS Reference Stations				
CRMS0220-H01	4.19	0.31	21.90	21.59
CRMS0248-H01	4.10	0.28	25.30	25.02
CRMS0253-H01	4.27	0.26	26.19	25.93
CRMS0261-H01	2.14	0.16	23.86	23.70
CRMS4218-H01	1.76	0.09	27.33	27.24
CRMS6303-H01	3.14	0.26	23.66	23.40
Overall	3.26	0.09	27.33	27.24

*Note: Calculations are based upon all available hourly readings at each station through October 11, 2017.

fresh water from the Gulf Intracoastal Waterway, the Davis Pond Freshwater Diversion Project, and rainfall likely has had a moderating effect on salinities. Post-construction modeling indicated that the upper Barataria Basin salinities in this area were not significantly impacted by the Davis Pond Freshwater diversion because they were already dominated by freshwater sources (Neupane 2010). Finally, the overall range of salinities for project area stations was 14.06 ppt less than the overall range of CRMS-Wetlands reference stations.

Yearly mean salinities are presented in figure 11 for all continuous recorder stations listed inside and outside of the project area. Stations were grouped by project or reference area. For this graphic, calculations were made only for the date range where all recorder stations had simultaneous data collection periods (February 26, 2010 through October 11, 2017) in JMP®, version 13. Graphs were produced in Microsoft Excel® 2010. Note that the stations inside the project boundary consistently had the lowest mean yearly salinities, at or below 2.0 ppt for the entire period of record.

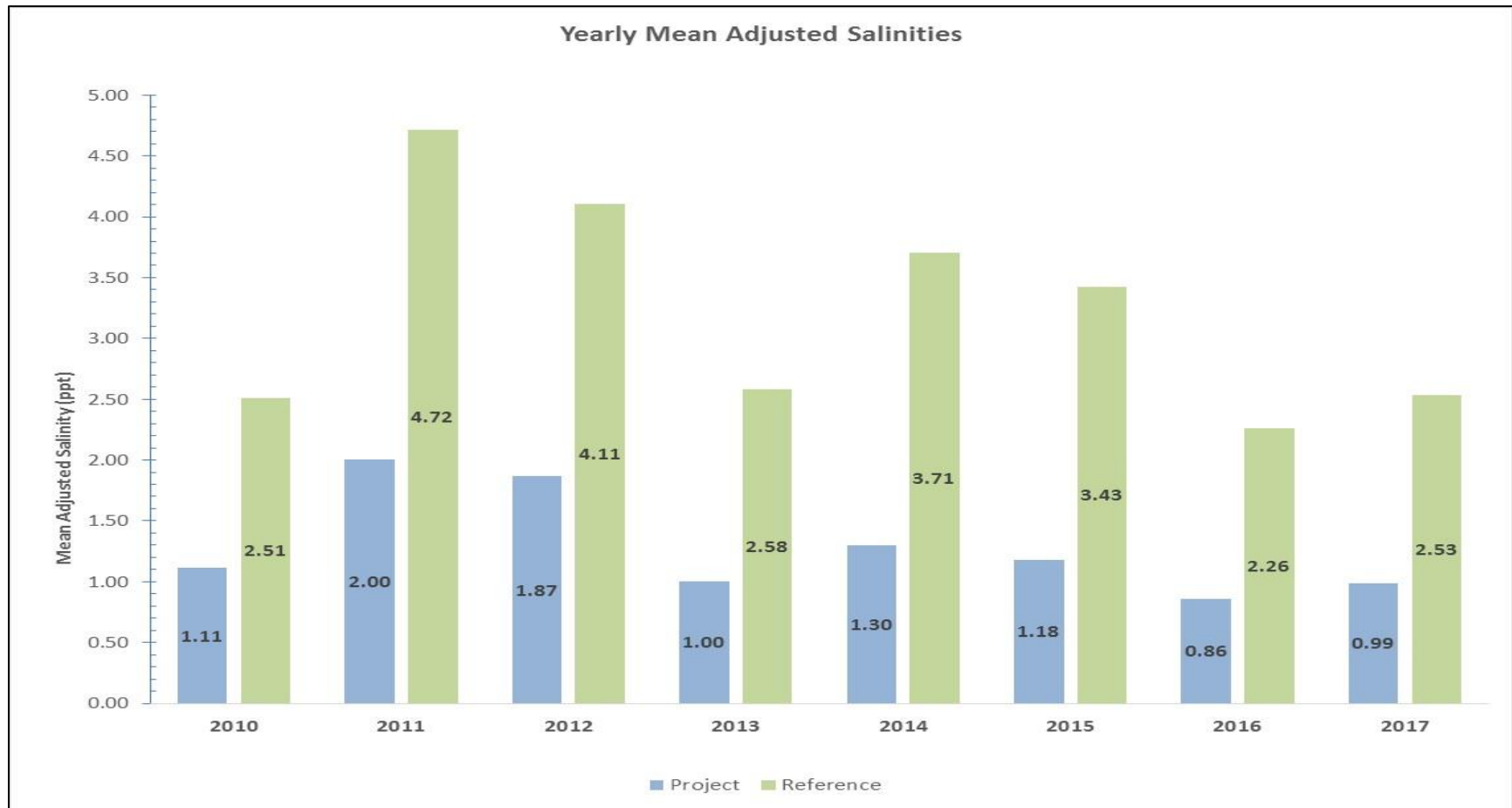


Figure 11. Yearly mean salinities for all open water continuous recorder stations inside and outside of the BA-02 project area.

Vegetation

Project-specific vegetation data were collected during the fall of 1996, 1999, 2000, 2002, 2005, 2008, 2012, and 2016 (figure 12). Each sampling station was marked with a PVC pole at the southeast corner, which allowed for data collection on repeated visits provided the station was not lost or destroyed by a natural or human disturbance. Station coordinates were collected at the southeast corner pole with a Differential Global Positioning System (DGPS) to facilitate repeated sampling. The corner pole position for each station was recorded in the Universal Transverse Mercator (UTM), North American Datum of 1983 (NAD83), Meters coordinate system. During data collection, a 6.6 ft x 6.6 ft (2 m x 2 m) Braun-Blanquet grid was placed over the southeast corner pole and oriented so that each side faced a cardinal direction. Species composition, percent cover by species and total percent cover data were recorded for the area inside the grid using ocular estimates near the end of the growing season. Total vegetation cover and cover of each layer (tree, shrub, herbaceous, carpet) was estimated between 0 and 100% (Folse et al. 2012, 2014). The sum of the vegetation layers could exceed 100 percent because of overlapping canopies. The average height of the dominant (that is, greatest percent cover) species was measured. Plant species nomenclature followed the USDA PLANTS Database (USDA, NRCS, 2018).

For CRMS0190 (figure 13), vegetation data were collected for consecutive years during the fall of 2006 through 2017 inside a 200 m² data collection area (DCA) within the 1 km² site. As with all CRMS-*Wetlands* sites, CRMS0190 has 10 vegetation stations located along a transect which runs diagonally inside the 200 m² DCA. This site is an oligohaline spikerush marsh community type (Visser et al. 1998). Data collection occurred within ten 6.6 ft x 6.6 ft (2 m x 2 m) stations along a 927.8 ft (282.8 m) transect within the 256.2 ft x 256.2 ft (200 m x 200 m) CRMS site (Folse et al. 2012, revised 2014) in the same manner as described for project-specific vegetation plots. In addition, vegetation data was collected from CRMS-*Wetlands* sites outside the project area (figure 6).

Data Analysis Methods for Vegetation:

The project-specific and project CRMS data were entered into an electronic format where Coastal Protection and Restoration Authority/Thibodaux Regional Office (CPRA/TRO) personnel followed Quality Assurance/Quality Control (QA/QC) procedures prior to data analysis as stated in Folse et al. (2012, revised 2014) and analyzed for mean cover, species composition, and Florisite Quality Index (FQI) following methods described in Cretini et al. (2009). Salinity categories were assigned to the vegetation data based upon what marsh type the individual species were most commonly found. Categories included fresh, intermediate, brackish, and saline, as well as transitional categories such as fresh-intermediate, intermediate-brackish, and brackish-saline using Visser classifications. Eight years of vegetation cover and composition data from the BA-02

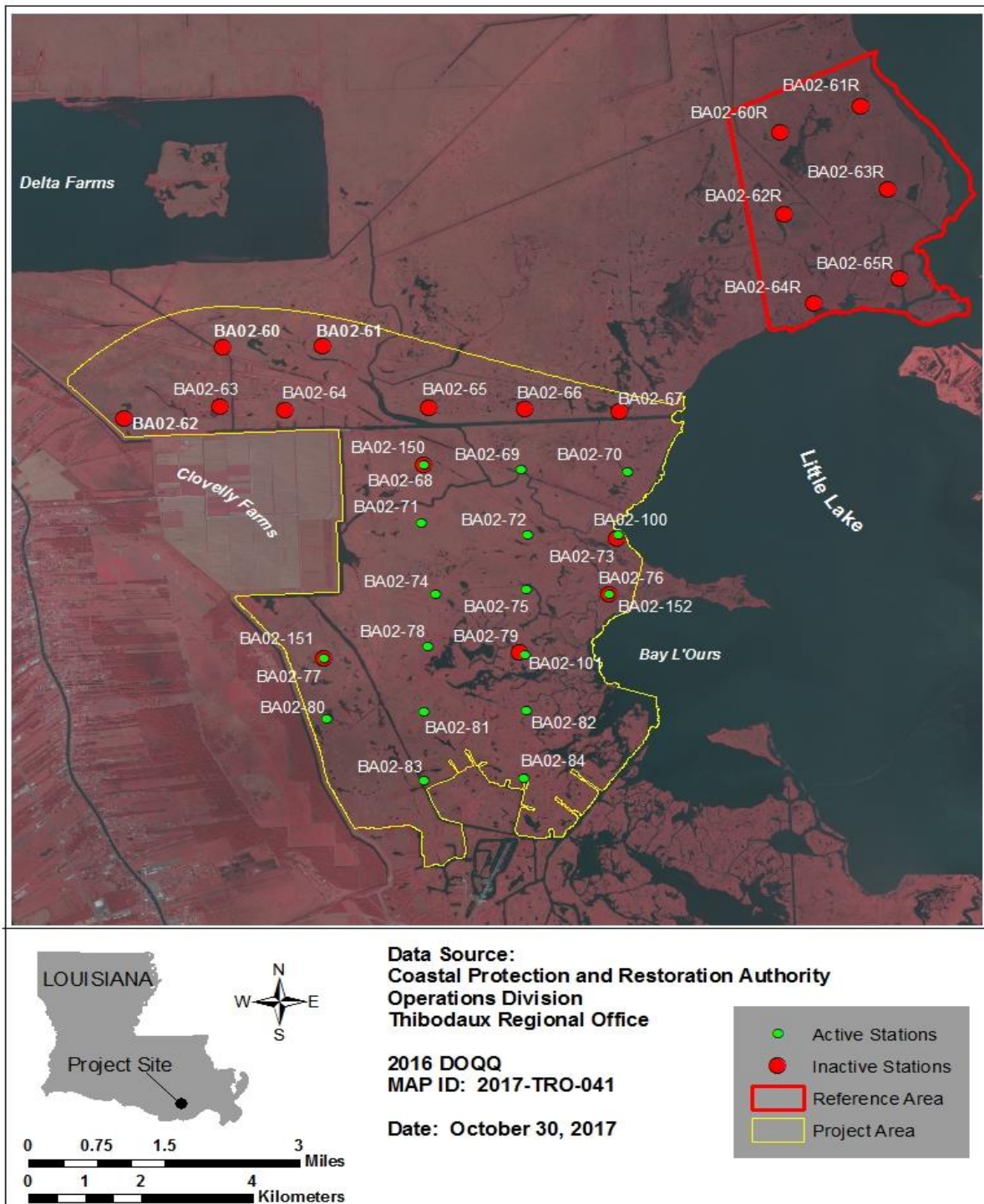


Figure 12. Project-specific vegetation and soils data collection stations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

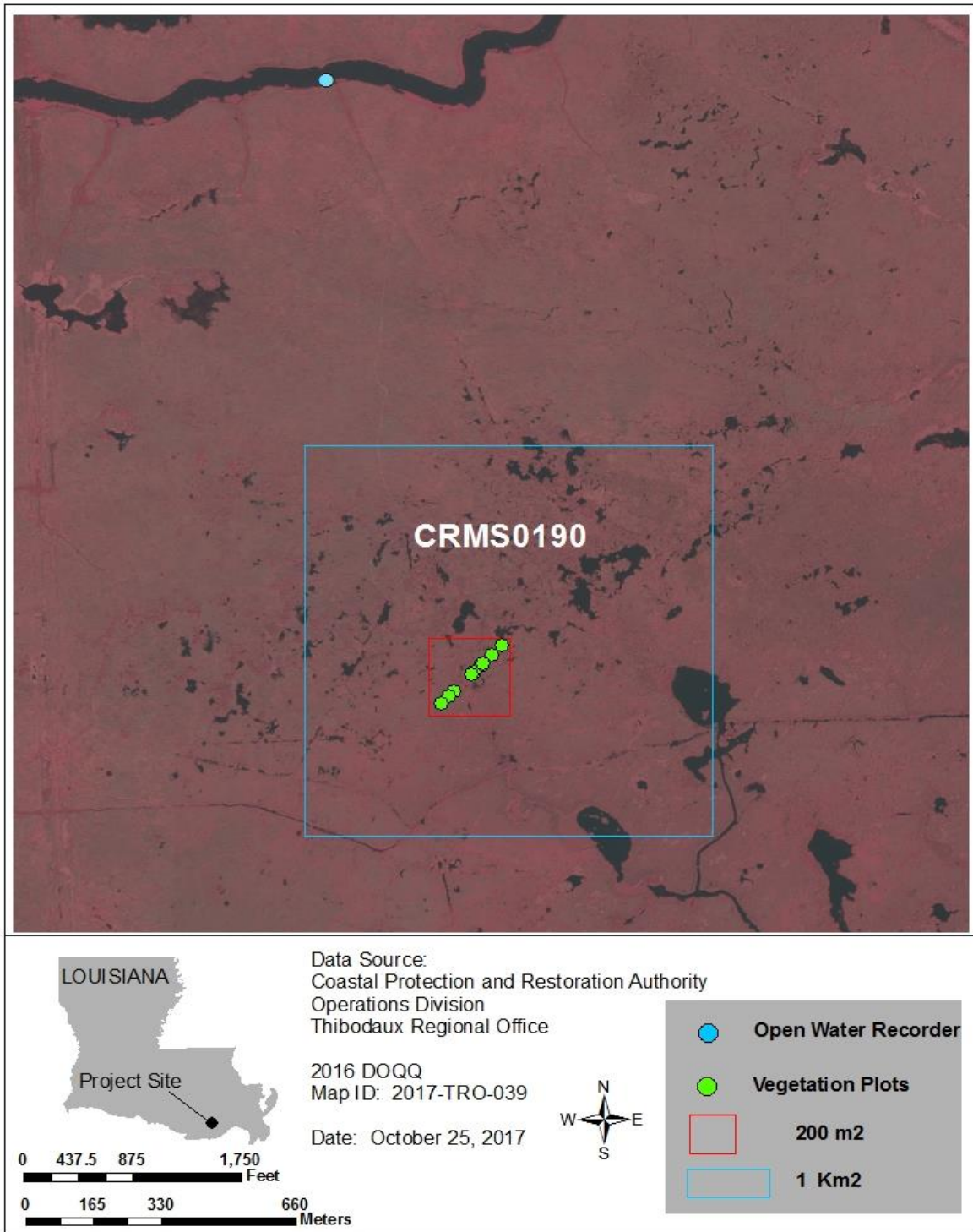


Figure 13. Location of CRMS0190 vegetation stations and open water recorder station.

project were used to determine the FQI over time for project stations as well as CRMS0190 inside the project area. In addition to mean cover, FQI, and salinity, a Vegetation Volume (VV) was calculated to provide not just the quality of the vegetation, but to get an idea of the productivity of the marsh. FQI is not a metric which entirely captures the project's goal to increase or maintain the relative abundance of intermediate marsh plants. It is not intended as a definitive tool towards this goal, but it may add some depth to the information gleaned from mean cover, species composition, and Vegetation Volume (VV) data. The FQI is used to quantitatively determine the condition of a particular habitat using the plant species composition (Cretini et al. 2009). It has been regionally modified for coastal Louisiana by a panel of local plant experts in order to determine changes in wetland conditions based upon the presence of non-native, invasive and disturbance-prone species across community types. The coefficient of conservatism (CC) score is a score from 0 to 10 assigned by the panel to flora and is used to calculate the FQI (Appendix D). Species are scored higher if they are dominant (9-10) or common (7-8) in vigorous coastal wetland communities, not as high if they occur primarily in less vigorous coastal wetland communities (4-6), even lower if they are opportunistic users of disturbed sites (1-3), and lowest if they are invasive plant species (0). The panel did not assign CC scores to 1) submerged aquatic vegetation, 2) parasitic species, 3) plants identified only to genus or family, or 4) unidentifiable plants. Non-native species were assigned a score of 0 by the panel. Plants identified only to genus were assigned a CC score for the species if only one species was on the list for that genus. The mode of the species scores was assigned to a plant if it was identified only to genus and more than one species for the genus was listed, provided the CC scores for those species were within a 3 point range. No CC score was assigned to a plant within the genus if the CC scores for the species had a wider range than 3 points. If *Distichlis spicata* was present, it was assigned a community-specific CC score; a high score in healthy brackish and salt marshes where it is a codominant, and a low score in fresh and intermediate marshes where its presence is indicative of a disturbance.

The Vegetation Volume is used to quantify the volume of vegetation layers at project or CRMS marsh sites. Unlike the FQI, which is an indicator of quality, the VV is useful in determining if vegetation cover has been maintained, increased, or decreased throughout the years. The VV incorporates cover data as well as height data (m^3) at each vegetation layer (e.g. tree, shrub, herbaceous, carpet). To calculate the VV, the percent cover (m^2) and height (m) were multiplied for each of the four vegetative layers at a station. Then the layer volumes (m^3) were added together.

Data Analysis Methods for Project-Specific Vegetation:

The mean percent cover was calculated for vegetation species inside the BA-02 project and reference area station for each sample year. The FQI was estimated using the Cretini and Steyer protocol (2011). Reference areas selected to the north and northeast of the project boundary were eliminated due to land rights issues during late spring 1997. The mean FQI for each sample year

is indicated along with a trendline created from these values. The mean percent cover of Visser marsh vegetation types were broken up into salinity categories for each year of available data. VV was also calculated, based upon the mean cover of vegetation layers and the layer heights.

Project-Specific Vegetation Results and Discussions

Mean percent cover of the dominant species *Spartina patens* (Ait.) Muhl. (marshhay cordgrass) has decreased by 38% since construction in 2000, however it was higher in 2016 (sixteen years post-construction) than in 1996 (four years pre-construction) when monitoring began (figure 14). Peak mean cover of this species occurred just prior to construction completion in 2000 after a steady increase from 1996. Mean cover values of *Sp. patens* have remained above those in 1996, with the highest values occurring post-construction. Species diversity varied throughout the years. The highest diversity occurred during preconstruction years 1996 and 1999 and the lowest occurred in 2002, two years post-construction. In 2005 data collection occurred two months after hurricane Katrina's landfall and diversity greatly increased as a result of this disturbance. Data collection in 2008 occurred approximately two months after hurricanes Rita and Ike and diversity remained high, but the overall mean cover decreased.

Despite a severe drought which lasted from September 1999 through June 2001 in southeastern Louisiana, mean percent cover for drought intolerant species such as *Sagittaria lancifolia* L. (bulltongue) and *Polygonum punctatum* Ell. (dotted smartweed) increased substantially by 2005. Combined mean cover for 2005 was higher than any other year of vegetation monitoring. The influx of freshwater from hurricane Katrina, and a return to normal rainfall patterns was enough to substantially increase the cover of intermediate to fresh marsh species such as *Schoenoplectus americanus* (Pers.) Volkart ex Schinz & R. Keller (chairmaker's bulrush) and *Eleocharis* R. Br. (spikerush).

The FQI and the mean cover followed a similar trend and tracked each other between 1996 and 2016. This is because *S. patens*, the species with the greatest cover, has a high cc score and, therefore, has a large impact on the FQI value.

The breakdown of vegetation into salinity categories using mean cover values of species present provides an idea of how the project area marsh types have fluctuated through the years (figure 15). In 1996, the project and reference areas were similar. Both contained predominately fresh to intermediate marsh types, as well as some intermediate-brackish marsh, and very little brackish-saline marsh. By the time of construction in 2000, the project marshes shifted to predominately intermediate-brackish, however by 2005 (five years post-construction) they were mainly fresh to intermediate with some intermediate-brackish. In 2008 the project area marshes were again

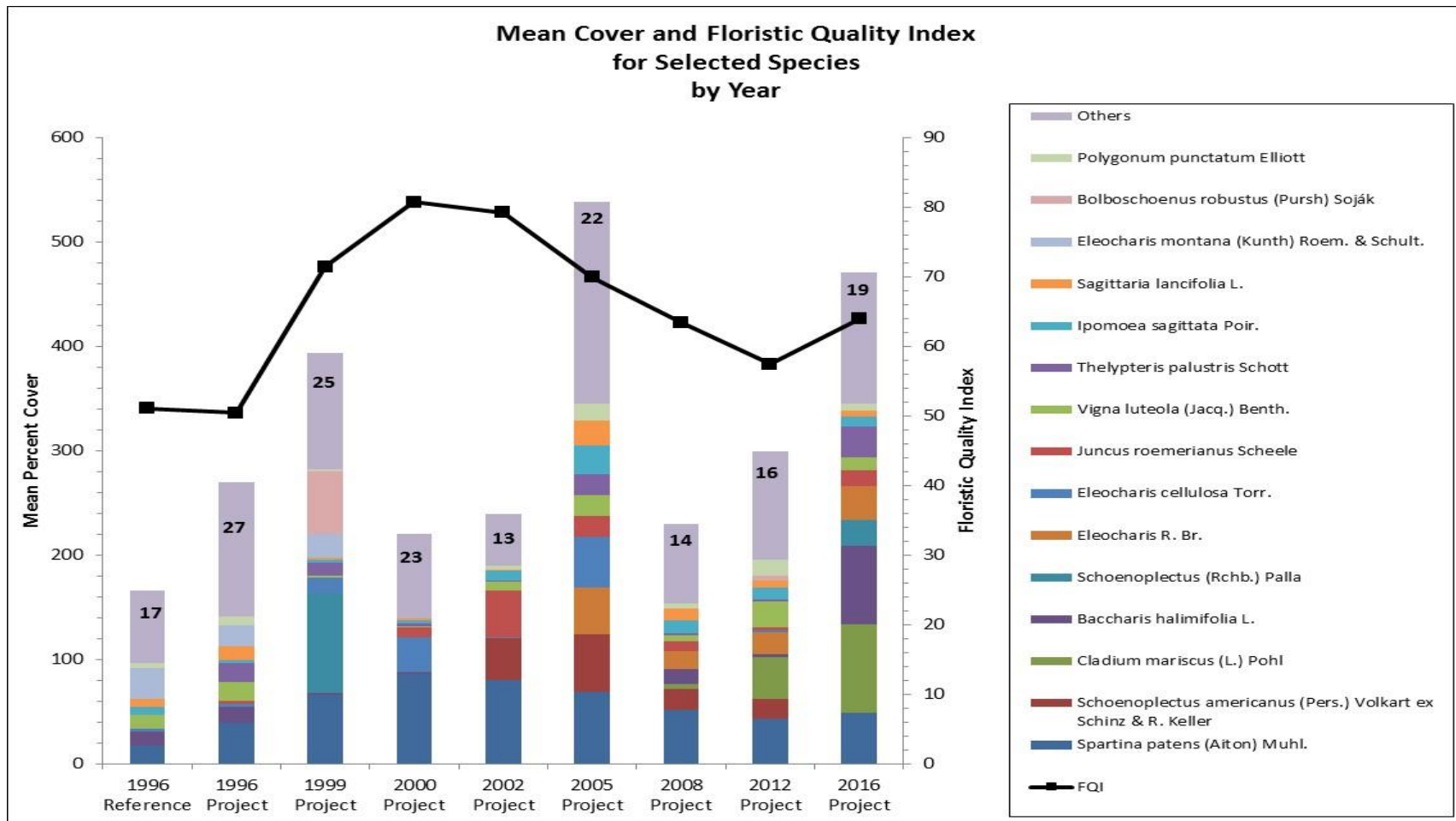


Figure 14. Project-specific mean percent cover for selected species by project and reference area by year. The yearly mean FQI scores are represented by the markers along the black trend line. Note: Additional species not listed in the legend are indicated as a count on the bar graph in the “others” category for each year.

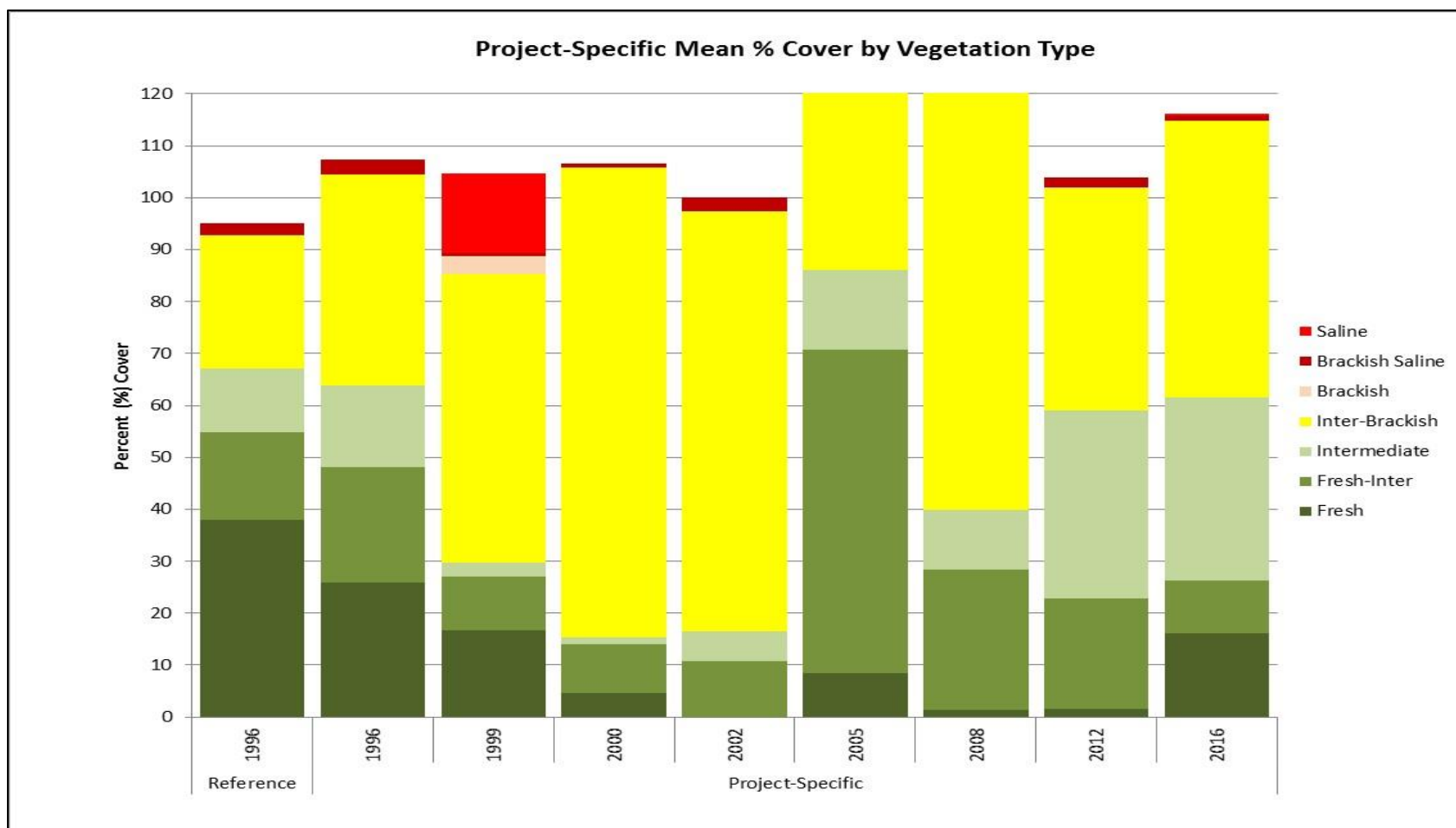


Figure 15. Distribution of salinity categories by sample year based upon mean percent cover of species found inside of 4m² project-specific and project reference vegetation plots for the BA-02 project.

predominately intermediate-brackish, however by 2016 the mean cover of fresh, fresh-intermediate and intermediate marsh vegetation increased again.

The VV within the BA-02 project area steadily declined in the years between construction in 2000 and 2012, twelve years post-construction (figure 16). In 2012 the VV was less than half of its pre-construction metric. There was a dramatic decrease in 2005 which points to likely effects from hurricane Katrina as well as other powerful tropical systems which impacted the area in the following years. A substantial recovery occurred between 2012 and 2016, where the VV doubled its value and increased to within 0.12 m³ of its 1999 pre-construction level. The VV and FQI followed a similar pattern throughout the years.

Data Analysis Methods for CRMS Vegetation:

For the project and reference CRMS sites, the data were entered into an electronic format where CPRA/TRO personnel followed QA/QC procedures and saved to the Louisiana Department of Natural Resources (LDNR) database prior to data analysis as stated in Folse et al. (2012, revised 2014). The charting tool from the CRMS website, based upon the Cretini and Steyer protocol (2011) was utilized to determine mean percent cover, species composition, and FQI within these sites for each year of data collection. As with the project-specific analysis, salinity categories were assigned to the CRMS vegetation data based upon what marsh type the individual species were most commonly found.

CRMS Vegetation Results and Discussions

Within the project CRMS site (CRMS0190) there has been an overall downward trend in the mean percent cover for the dominant species *S. patens*, and with it the FQI, with some variations in between (figure 17). Overall peak mean percent cover for all species combined occurred in 2008. The lowest combined mean cover occurred in 2011, however it rebounded to its second-highest cover by 2017.

With the exception of years 2011 and 2012, FQI scores for CRMS0190 have remained higher than all other CRMS sites within the same vegetation (intermediate marsh) type (figure 18). The CRMS0190 FQI scores are similar to other CRMS-*Wetlands* intermediate marsh sites in the Barataria Basin, with the exception of year 2011 (figure 19).

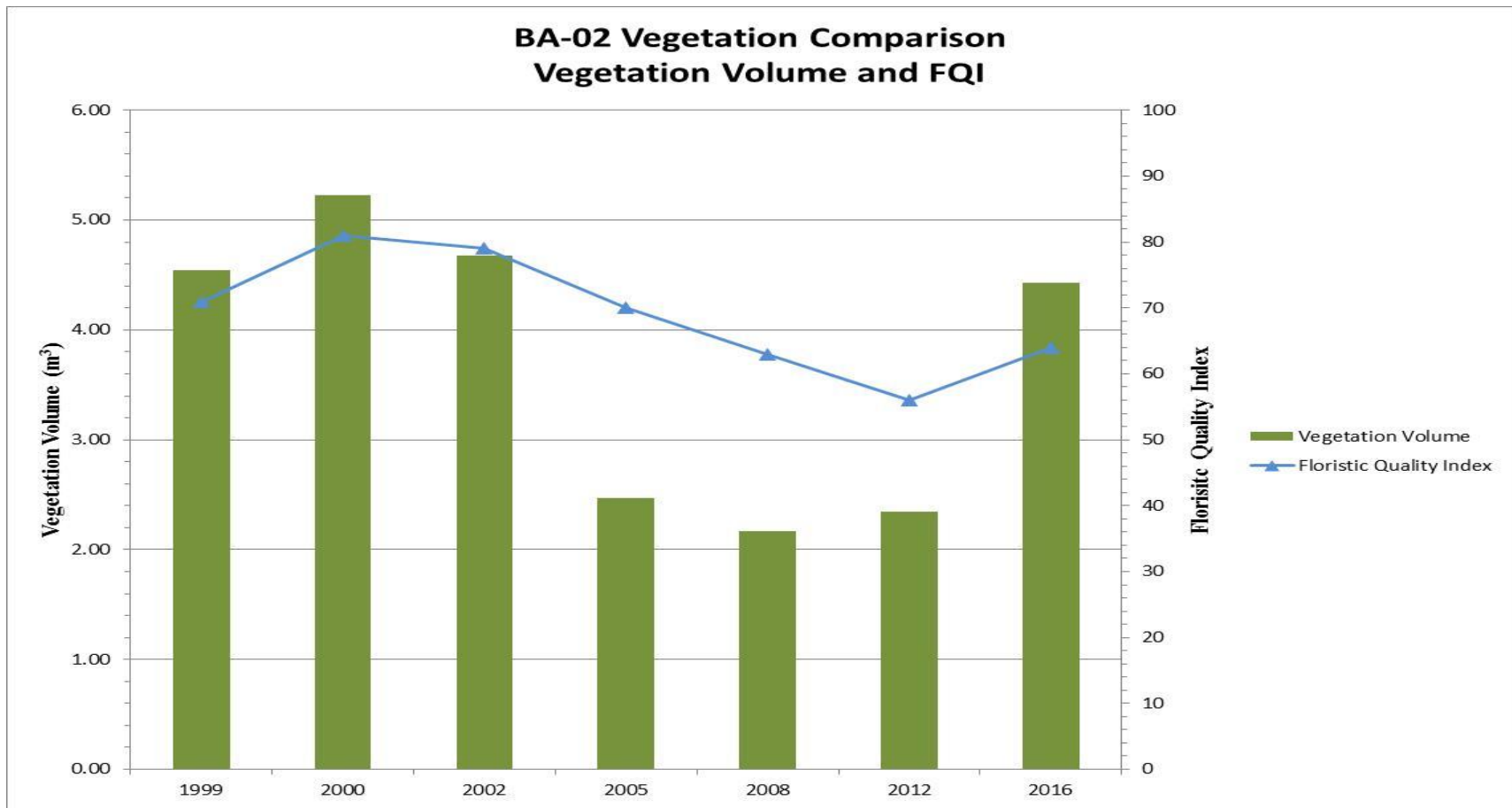


Figure 16. Vegetation Volume (VV) and FQI by year for the project-specific vegetation stations inside of the BA-02 project.

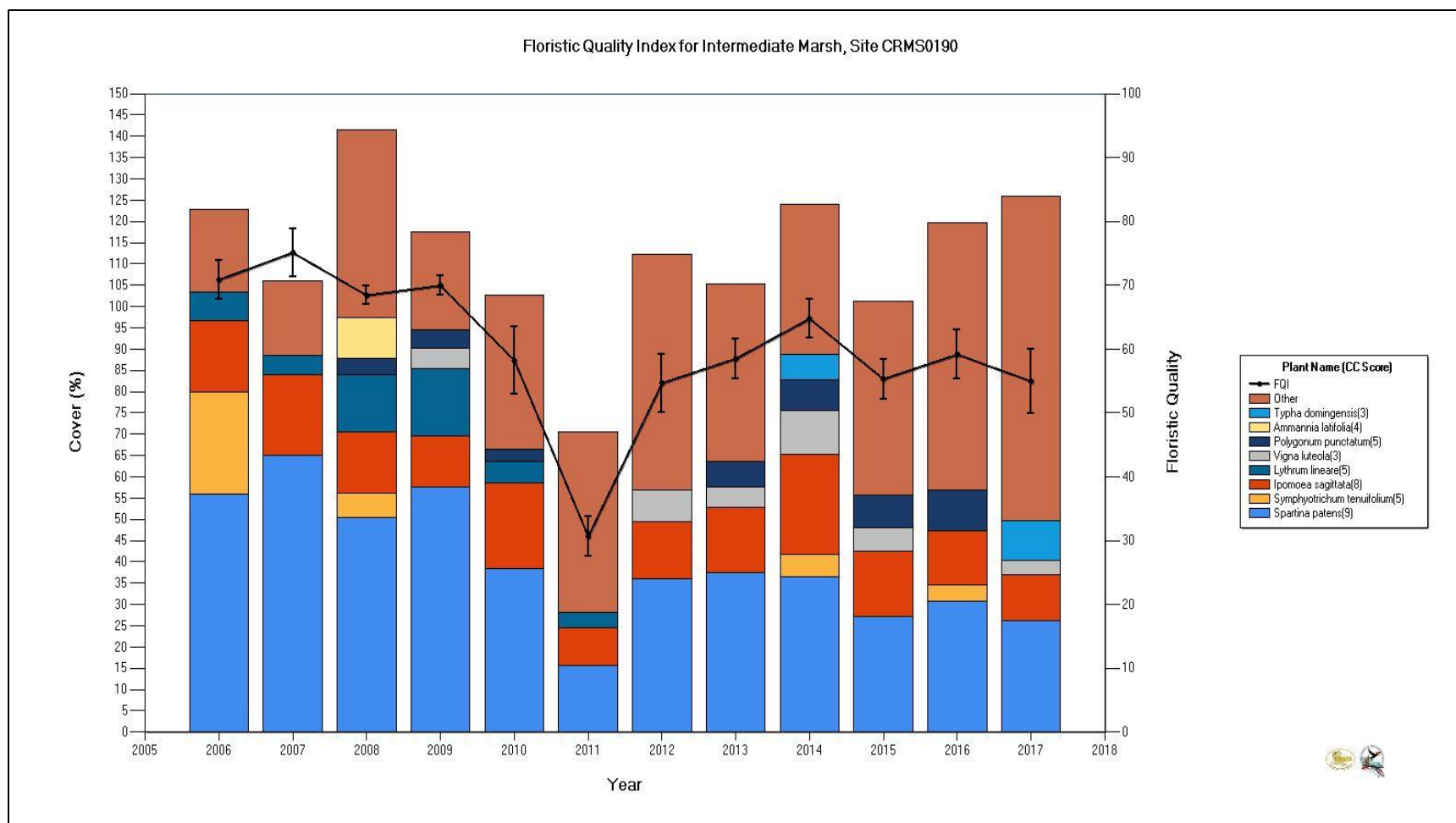


Figure 17. Mean percent cover for selected species at CRMS0190 by sample year. The mean FQI is represented for each year along the trendline.

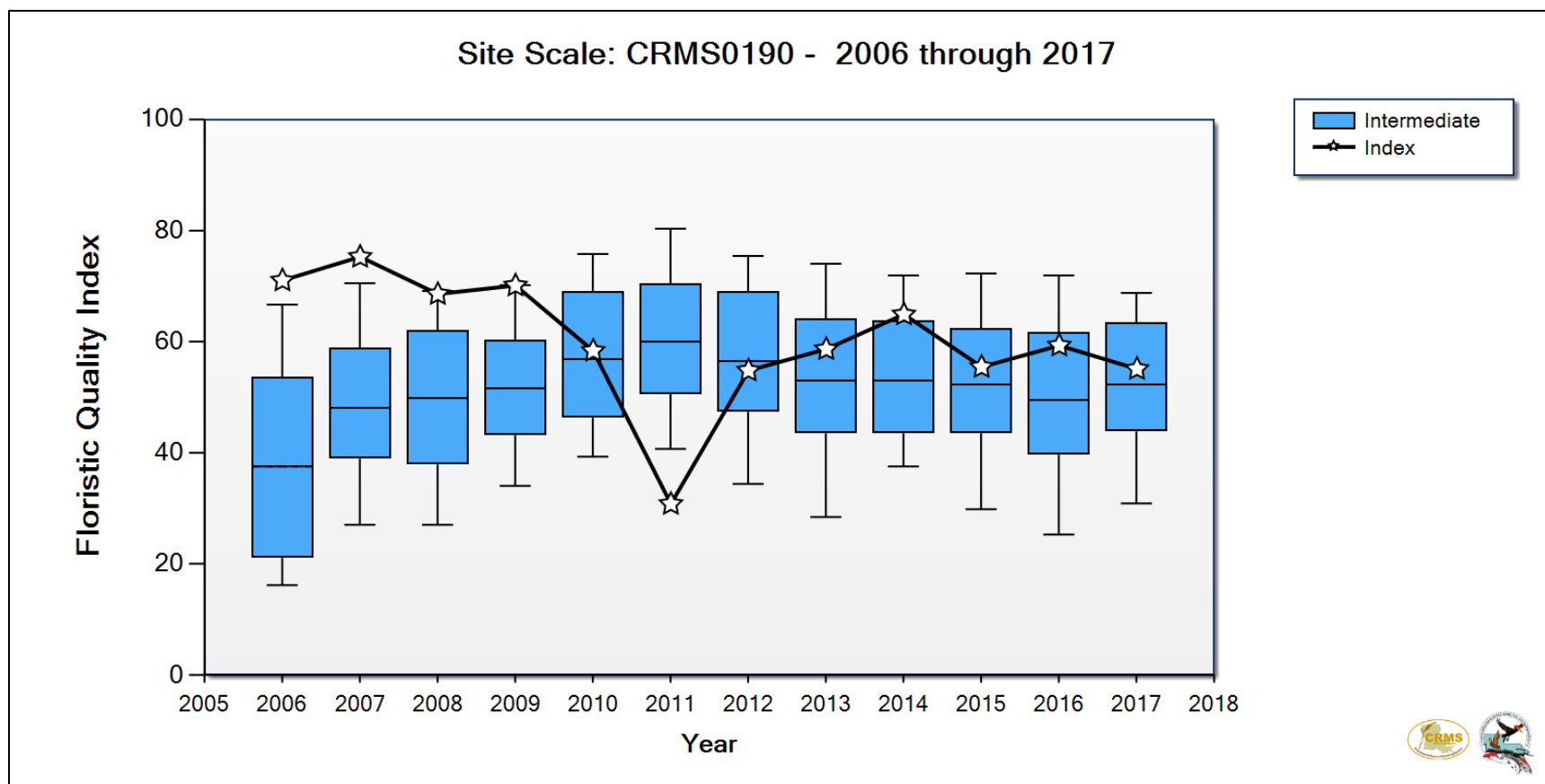


Figure 18. Time series chart of FQI scores for CRMS0190 indicating that it has been consistently characterized as an intermediate marsh. FQI Scores are represented along the trendline relative to a box plot of scores for all CRMS-Wetlands sites within the same marsh type for each year. Marsh type classification for each year was based upon the species composition at CRMS0190 at that year.

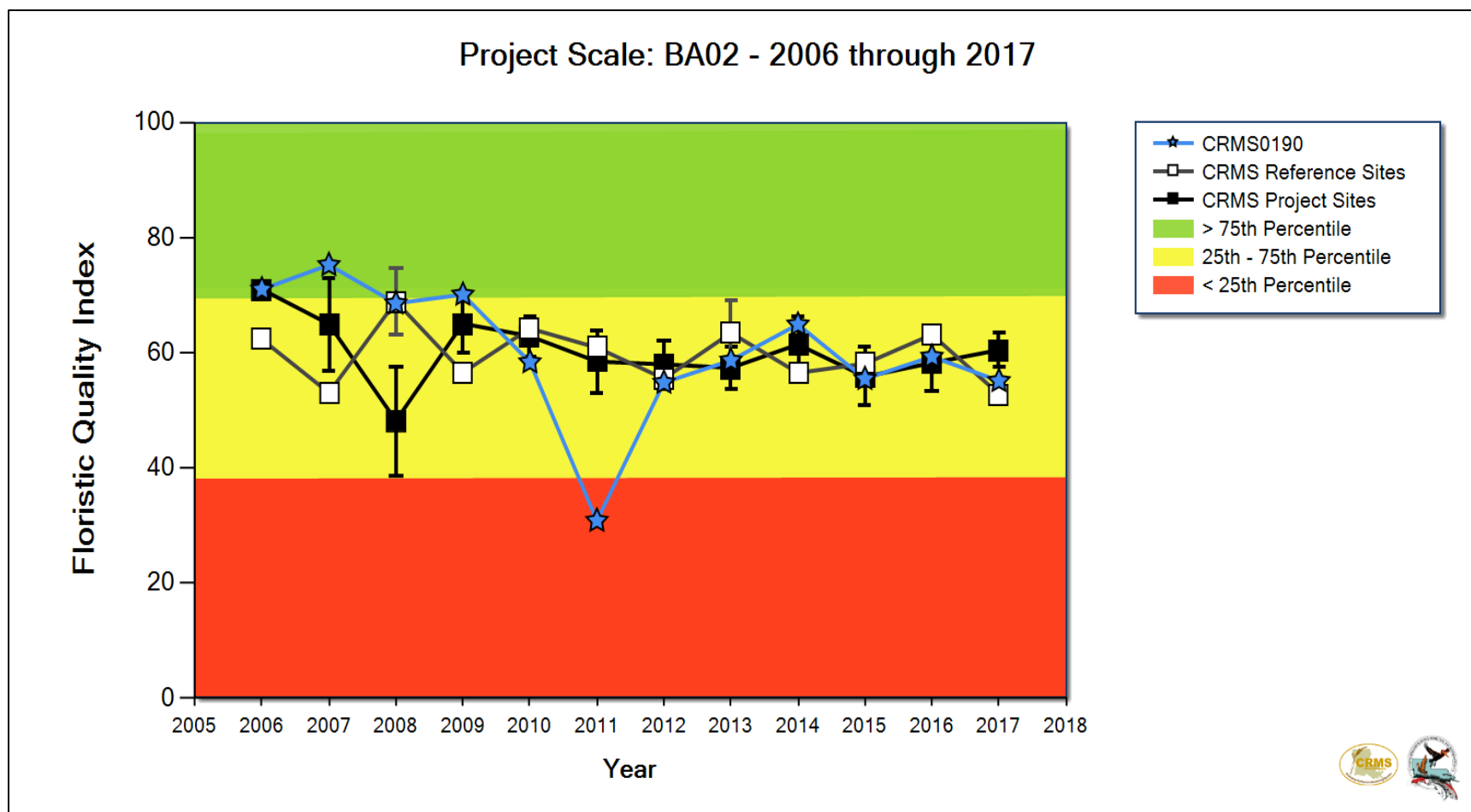


Figure 19. FQI scores comparing the CRMS0190 site to other CRMS-wetlands intermediate marsh sites in the Barataria Basin over time. Note that the FQI scores for CRMS0190 are similar to the other sites in this basin with the exception of year 2011

In addition to the project *CRMS-Wetlands* site, mean cover and FQI were determined for the reference sites outside the project area (figure 20). Four of the six sites were not established until 2007. As with the project site, *S. patens* was the dominant species. Both had high species diversity however, the species mix was not completely similar. The reference sites contained greater cover and presence of species indicative of slightly brackish marshes (i.e., *Schoenolplectus americanus*, *Eleocharis parvula*, *Juncus roemerianus*), whereas the project area site had high diversity and lower mean cover with a species mix more indicative of an intermediate marsh type (i.e., *Spartina patens*, *Vigna luteola*, *Ipomoea sagittata*) (Visser et al. 1998). The salinity data in table 6 as well as the vegetative salinity category breakdown in figure 21 further illustrates and supports this analysis. Mean cover of the dominant species *S. patens* generally experienced a downward trend for both the project and reference sites.

In an additional vegetation analysis, salinity categories were assigned to the CRMS vegetation data based upon the marsh types in which the individual species were most commonly found. Figure 21 indicates the salinity categories for the project and reference CRMS-*Wetlands* sites based upon their mean percent cover for years 2006 through 2017. Overall, the project site had more fresh to intermediate marsh types than the reference CRMS-*Wetlands* sites. In 2008 brackish-saline marsh vegetation began to show up in the project site, however this metric remained proportionately small, and the fresh to intermediate marsh types increased substantially in cover by 2017. Conversely, the intermediate-brackish marsh type decreased substantially inside the project site since 2006. The brackish, brackish-saline, and saline marsh types in the reference sites fluctuated slightly throughout the years, but these sites remained essentially more saline in their species composition than the project site due to their proximity to the Barataria Waterway. Also, in the reference CRMS-*Wetlands* sites, the fresh to intermediate marsh types decreased by 2017.

The VV was calculated and graphed along with the FQI for the project and reference CRMS-*Wetlands* sites for years 2006 through 2017 (figure 22). The project VV followed the FQI pattern from year to year. The exception was in 2017 when the VV noticeably increased while the FQI dipped slightly. This statistic was the result of a decrease in cover of high value intermediate marsh vegetation species, such as *S. patens*, while the overall volume of vegetation at the site increased. The same thing occurred in 2011 for the CRMS reference sites. The project VV metrics were not always similar to the CRMS-*Wetlands* reference sites from year to year. For instance, the highest VV score for the reference sites was in 2011, whereas that was the year it was lowest for the project site. Also, there was less variation from year to year in the reference VV and FQI scores. The VV patterns for the CRMS reference sites did not follow their FQI patterns in every instant from one year to the next, but the trends were similar.

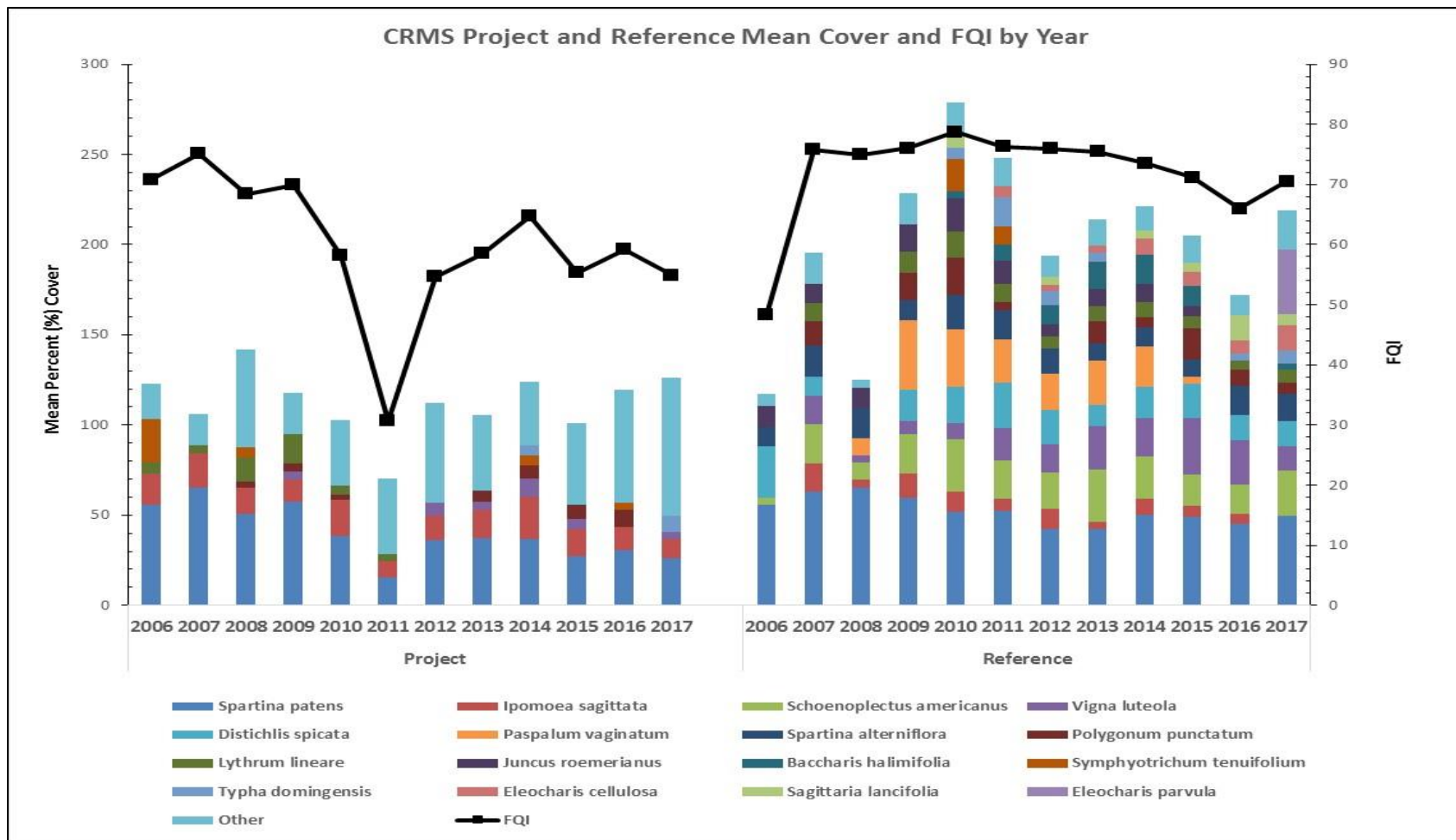


Figure 20. Project and reference CRMS site mean percent cover for selected species by year. The yearly mean FQI scores are represented by the markers along the black trend lines.

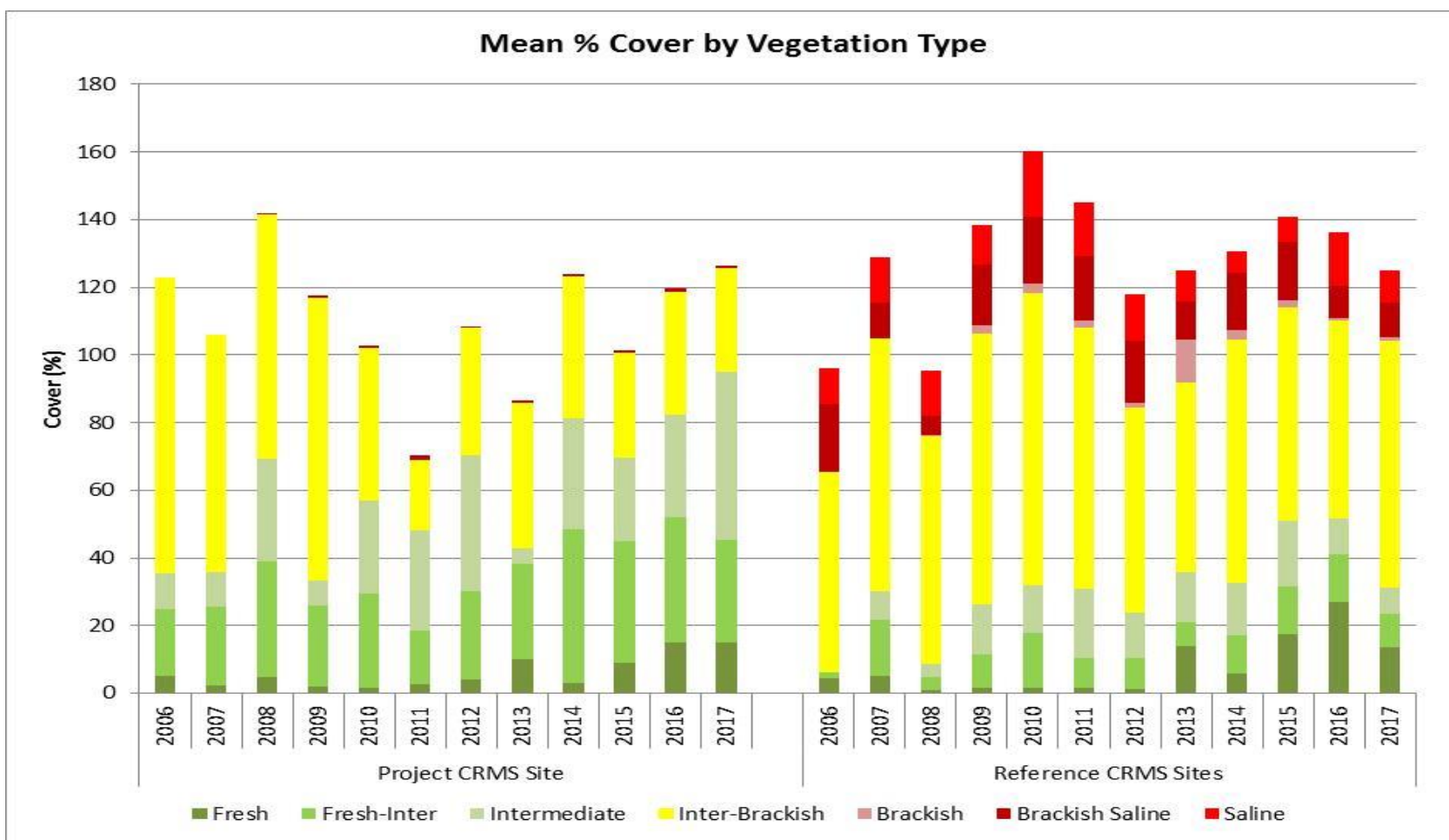


Figure 21. Distribution of salinity categories by sample year based upon mean percent cover of species found inside of 4m² CRMS project and reference vegetation plots for the BA-02 project.

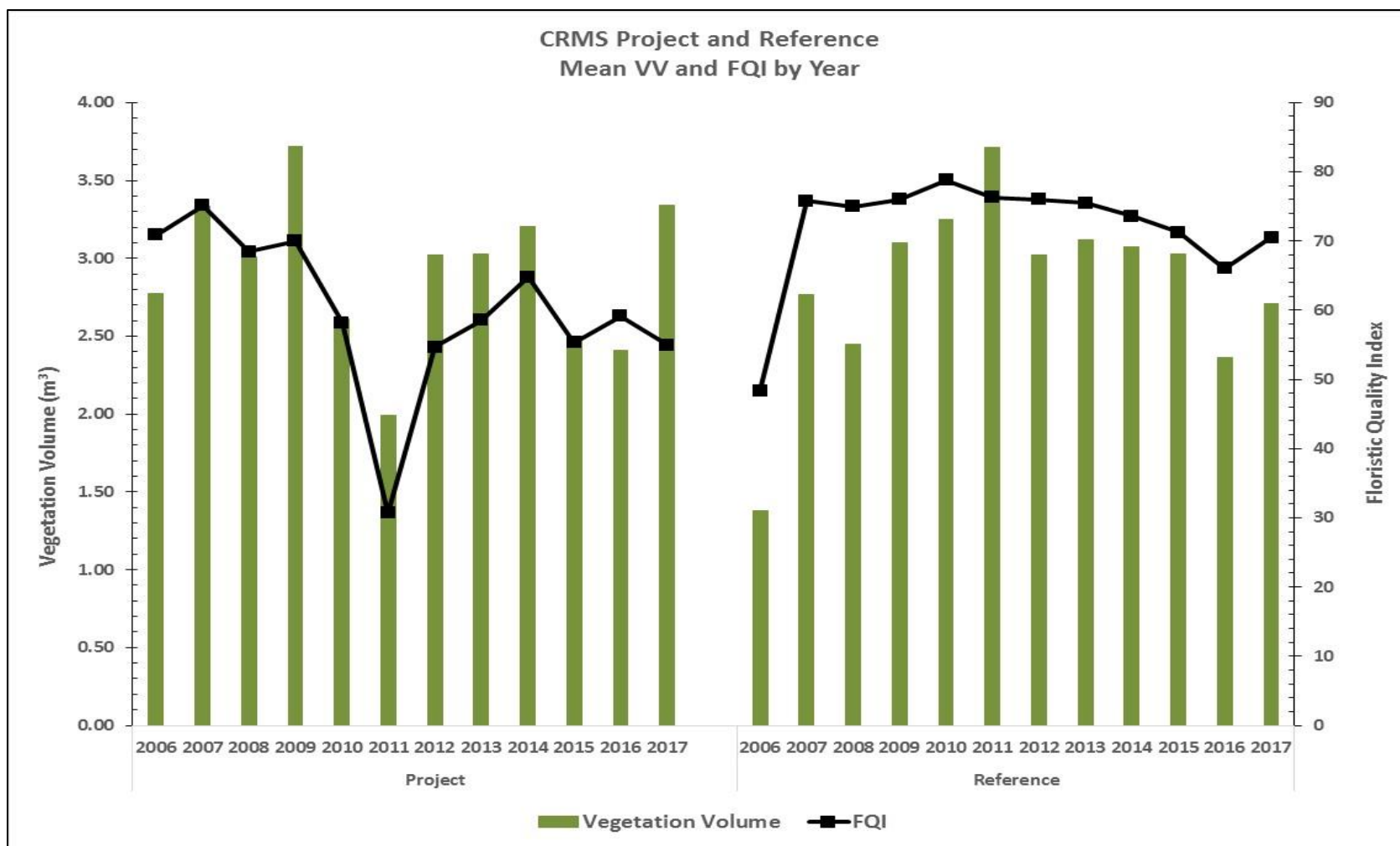


Figure 22. Vegetation Volume and FQI for CRMS-*Wetlands* project and reference sites for the BA-02 project.

Soils

Project-specific grab sample soils data were collected concurrent to vegetation sampling during the fall of 1996, 1999, 2000, 2002, 2005, 2008, 2012 and 2016. Soils data collection stations as well as sampling years were the same as those used for vegetation monitoring (figure 12).

In 2005, 2008, and 2012 CPRA contracted with Coastal Estuary Services (CES), LLC in Houma, Louisiana, for project-specific soils data collection and processing, and in 2016 soil data collection was conducted by CPRA biologists. Soil samples were taken with an 11.8 in (30 cm) stainless steel Meriwether corer, with an inside tube diameter of 4 in (10.1 cm) to a depth of 5.9 in (16 cm) using the protocol set forth in Folse et al. (2012). Soil cores were processed in order to determine the g/cm^3 bulk density and percent organic matter content. Grab sample analyses results were similar to those of the core samples and are not shown in this report to avoid redundancy.

In addition to project-specific soils data collection, three baseline soil cores were taken from CRMS0190 inside the project area. The cores were taken only once from the site at the time of its initial establishment. The cores were taken with an 11.8 in (30 cm) stainless steel Meriwether corer, with an inside tube diameter of 4 in (10.1 cm) to a depth of 11.8 in (30 cm) using the protocol set forth in Folse et al. (2012, revised 2014). Cores were extruded in the field and sliced into 1.57 in (4 cm) increments to a depth of 9.45 in (24 cm). They were placed on ice immediately and sent to the contracted soils lab. Soil cores were analyzed for bulk density (g/cm^3) and organic matter content (%). Core samples were taken at all CRMS-*Wetlands* sites using this methodology at the time of establishment, therefore comparisons can be made between CRMS0190 and similar sites throughout the coastal zone.

Project-Specific Data Analysis Methods for Soils:

Soils data deliverables were received by CPRA/Operations from CES. Individual station results were totaled and divided by the number of stations to determine the mean values for the two (2) variables that were consistently collected. These variables included organic matter content and bulk density.

Project-Specific Soils Results and Discussions

The BA-02 project contains areas that include both attached and floating marsh. Floating marshes have almost entirely organic substrates and are tied together by living plant roots in a peat mat (Sasser et al. 1995). Also, organic soils such as those found in the BA-02 project area generally have a bulk density of 0.2 to 0.3 g/cm^3 but can be as low as 0.04 g/cm^3 in a peatland soil (Mitsch and Gosselink 2000). It is the low mineral content which makes floating marshes



buoyant. Attached marshes have a higher mineral content in their soils due to the influx of suspended sediments over the marsh from nearby water bodies, lowering their buoyancy. Marshes with higher organic matter content in their soils conversely have lower bulk density. Additionally, the buoyancy of an intermediate marsh is demonstrably variable (Swarzenski et al. 1991), as its buoyancy has been shown to oscillate with seasonal variations in water levels in concert with the substrate bulk density. Oscillations do occur where floating marsh is present in the BA-02 project area. Intermediate marshes such as those inside of BA-02 tend to be most buoyant in the late summer and early autumn and least buoyant in the winter.

Note: The 2002 samples had values that were so low for all soil properties tested, that they were considered to be outliers. The soils laboratory did not perform bulk density measurements on the grab samples in 2002.

The core sample data indicate that the project has highly organic soils with low mineral content (figure 23). There was a continuation of the upward trend in mean organic matter content for project area stations in 2016 (figure 26). Although 2016 mean organic matter content was 1.5% lower than in 2005, it was 3.47% higher than in 2008, and 1.21% higher than in 2012. Mean bulk density also continued its upward trend in 2016. Mean bulk density almost doubled from 0.07 g/cm³ to 0.13 g/cm³ between 2005 and 2016. It increased by 0.03 g/cm³ between 2012 and 2016, which was the highest increase since 2005. Overall, the BA-02 project area soils have not altered much in the ten years since regular soil coring began.

CRMS Data Analysis Methods for Soils:

The raw data for bulk density and organic matter content were sorted by station and sample depth. Means were calculated for the three cores at each CRMS-*Wetlands* project and reference site at 1.57 in (4 cm) sample depth increments. Results for each variable are presented in figure 23.

CRMS Soils Results and Discussions

The soils data analysis for the CRMS-*Wetlands* project site illustrates that the marsh is highly organic with very low bulk density which indicates little to no mineral content. Mean organic matter content was consistently high (>75 %) for each of the 4 cm sample depth increments within the site (figure 24). Peak content occurred at the 12-16 cm sample depth. Mean bulk density for CRMS0190 was consistently low across all of the 4 cm sample depth increments. There was slight variability from increment to increment of soil depth for this site. The highest mean bulk densities occurred at the 4 cm and 16 cm sample depths, though they were both indicative of a highly organic floating marsh.



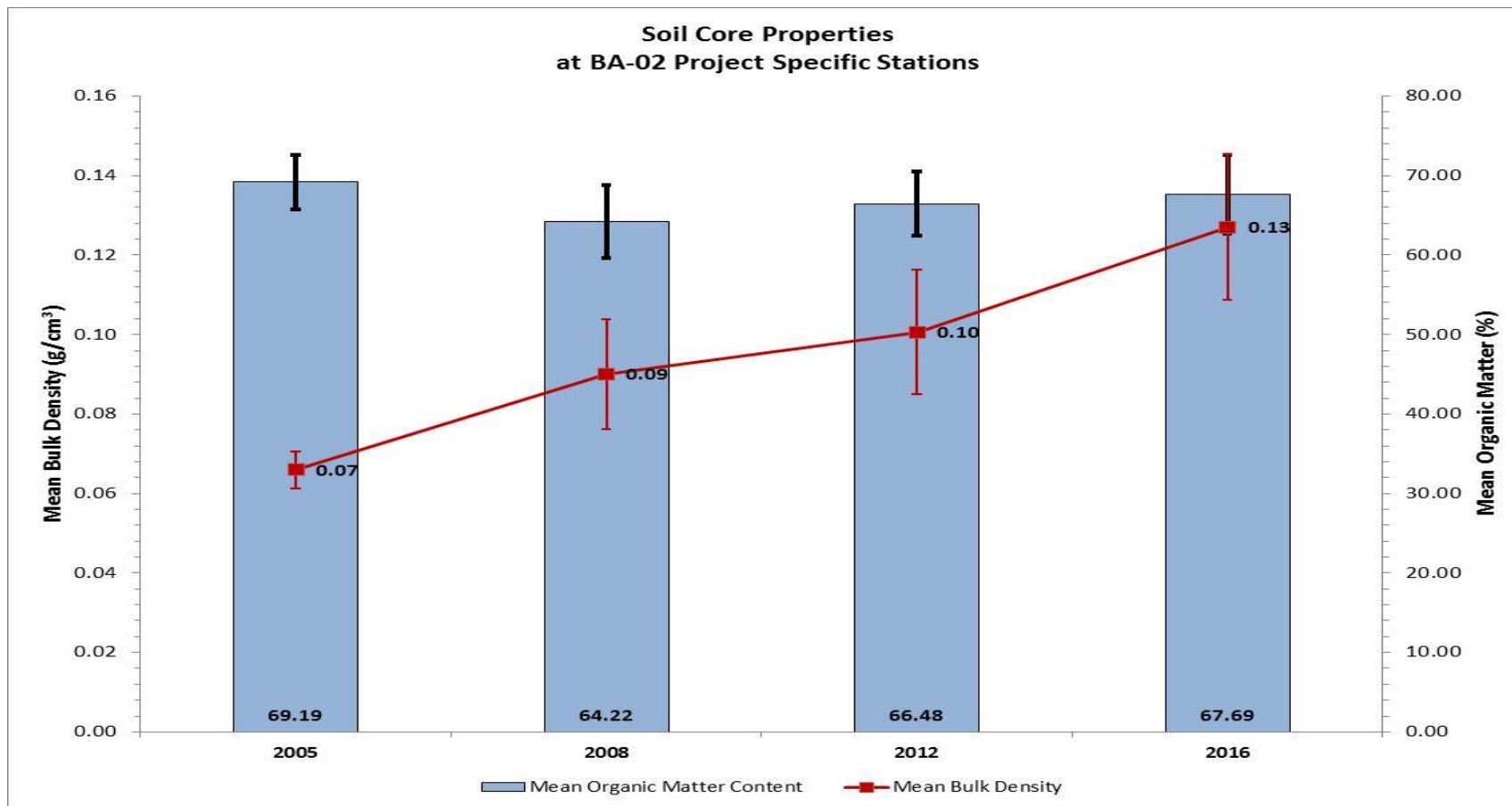


Figure 23. Mean bulk density and mean organic matter content for soil core samples collected at all BA-02 project-specific stations and reference station

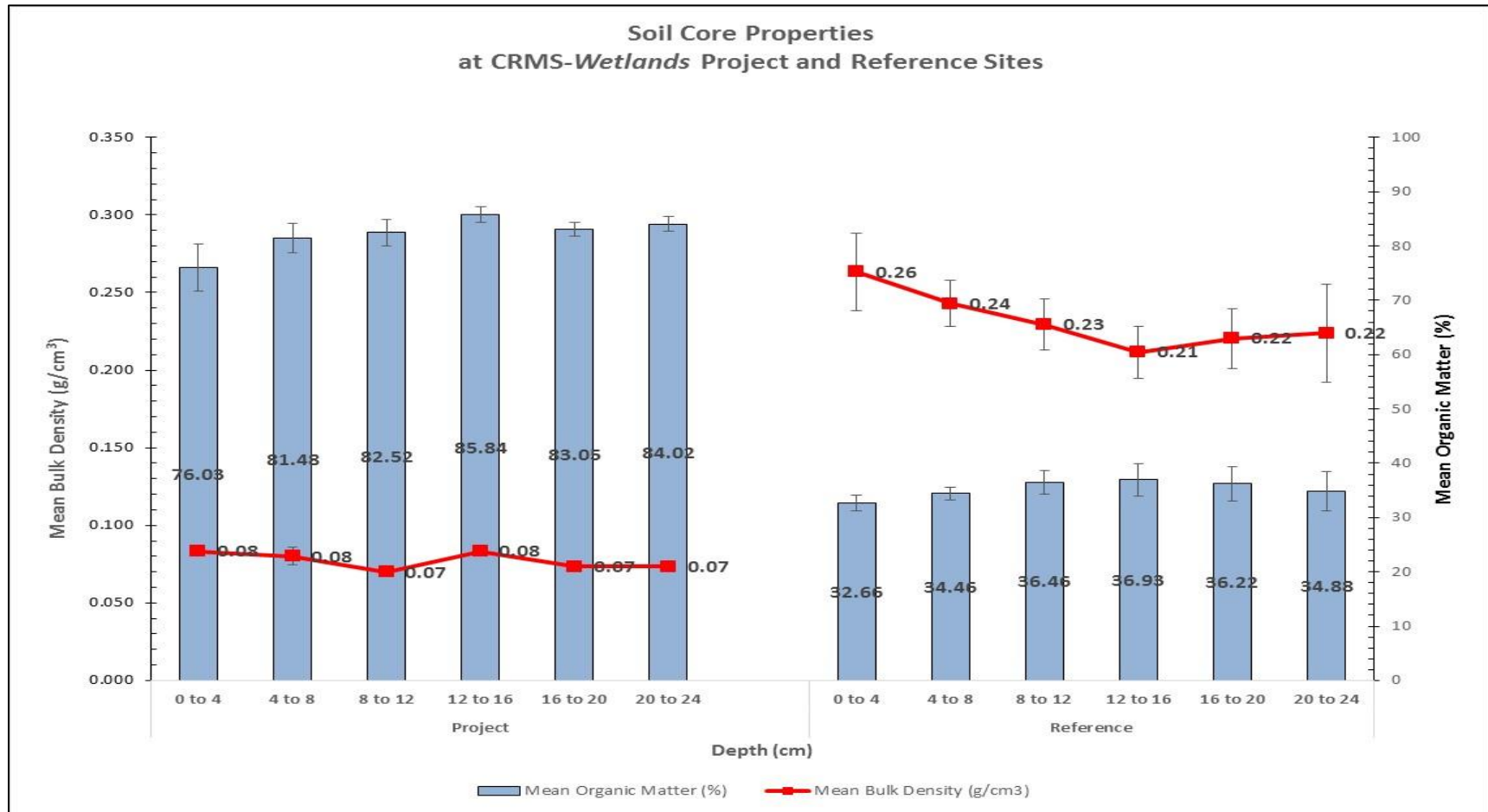


Figure 24. Mean bulk density and mean organic matter content for soil core samples collected at CRMS-Wetlands project and reference sites.

Conversely, the CRMS-*Wetlands* reference sites consistently had nearly double the mean bulk density than the project site across all soil depth increments. The mean organic matter content was less than half of the project site's values (<40%). Mean bulk density was lowest and mean organic matter content was highest at the 12-16 cm sample depth increment. Overall, the data was indicative of attached marshes with higher mineral content soils.

Shoreline Change

Shoreline position data for the GIWW to Clovelly Hydrologic Restoration (BA-02) project was collected pre-construction by CPRA personnel in 1993 and 1998, as well as 2000, 2003, and 2016 post-construction. CPRA personnel utilized sub-meter accurate DGPS equipment to collect the shoreline points along 21 randomly selected 300 ft (91.4 m) segments (figure 25). Shaw Coastal, Inc. was contracted by CPRA to document shoreline position along the same segments in 2005, 2008 and 2012. Shaw Coastal, Inc. personnel utilized a Trimble 5700 RTK base station with a Trimble 5800 rover unit; the data was stored in a Trimble TSCe data collector (Shaw Coastal, Inc. 2005).

Data Analysis Methods for Shoreline Change:

Georectified DGPS shoreline segments from each survey year were entered into ArcView GIS® Version 3.2 and converted to shapefiles. Polygons were created from these segments in order to have a pre-existing standardized area from which to calculate area and linear changes with polygons created from each data collection year (figures 25 and 26). Shoreline segments for each year were entered into ArcView GIS® as shapefiles. Each shapefile was entered into Autodesk Map © 2004 where polygons were created for the segments. Area and distance calculations were made between the polygons and segments for each year using the area command function in Autodesk Map© 2004. Data generated from these calculations were entered into a Microsoft Office Excel 2010 workbook and additional calculations were performed to determine the change rate per year for each shoreline segment. Bar charts were created for graphic representation of the data (figures 27 and 28).

The methods used to determine shoreline position from survey to survey allowed personnel to determine changes occurring between a five-year pre-construction time range and a 16-year post-construction time range to determine project effects. Additionally, because the DGPS equipment used for these surveys was sub-meter accurate, the shoreline segments could be georectified to aerial photography, which made it possible to generate data and produce images showing the shoreline changes.

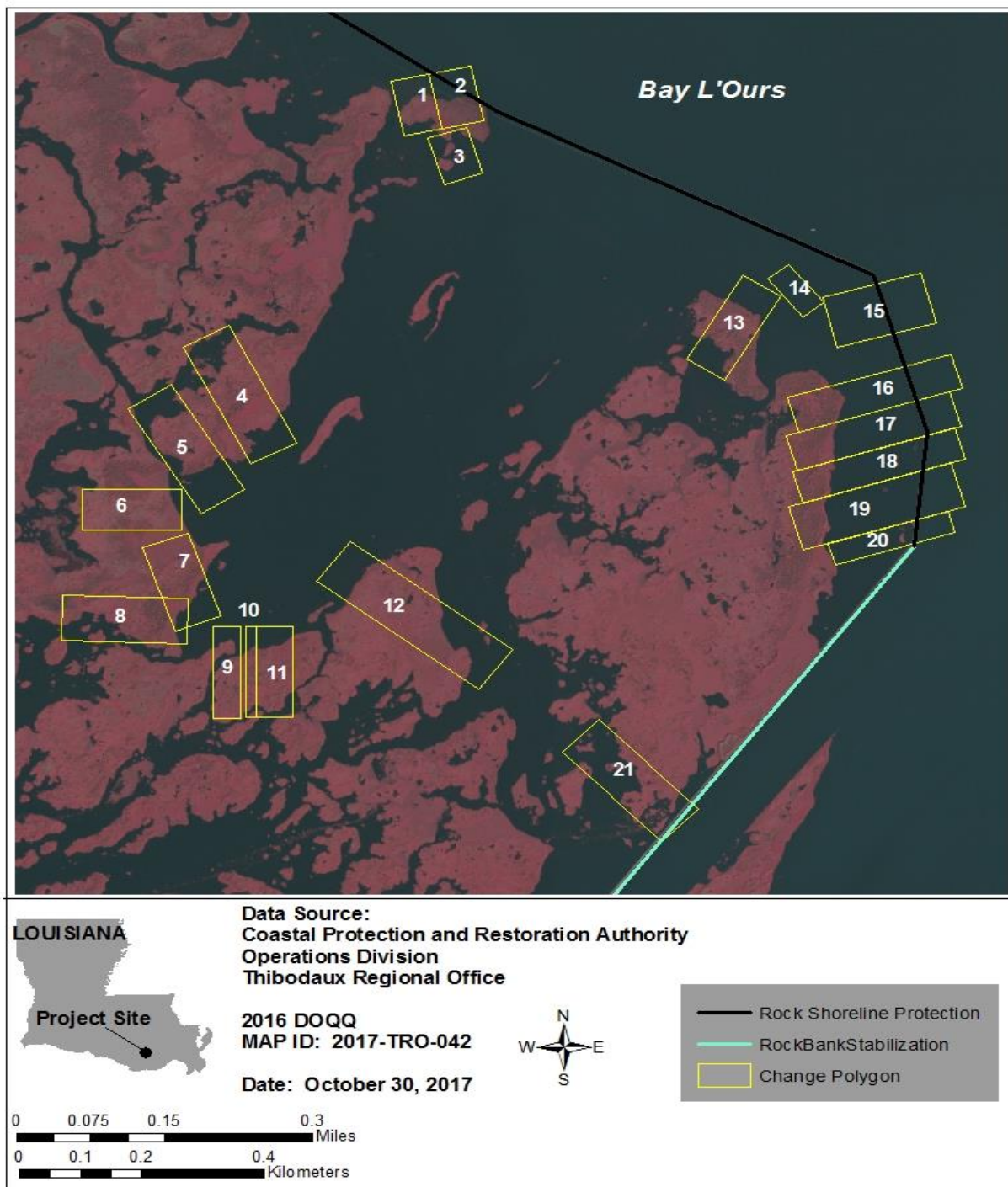


Figure 25. Change polygons for randomly selected shoreline segments 1-21 for the BA-02 project. Construction for the shoreline protection rock dike was completed in October 2000.

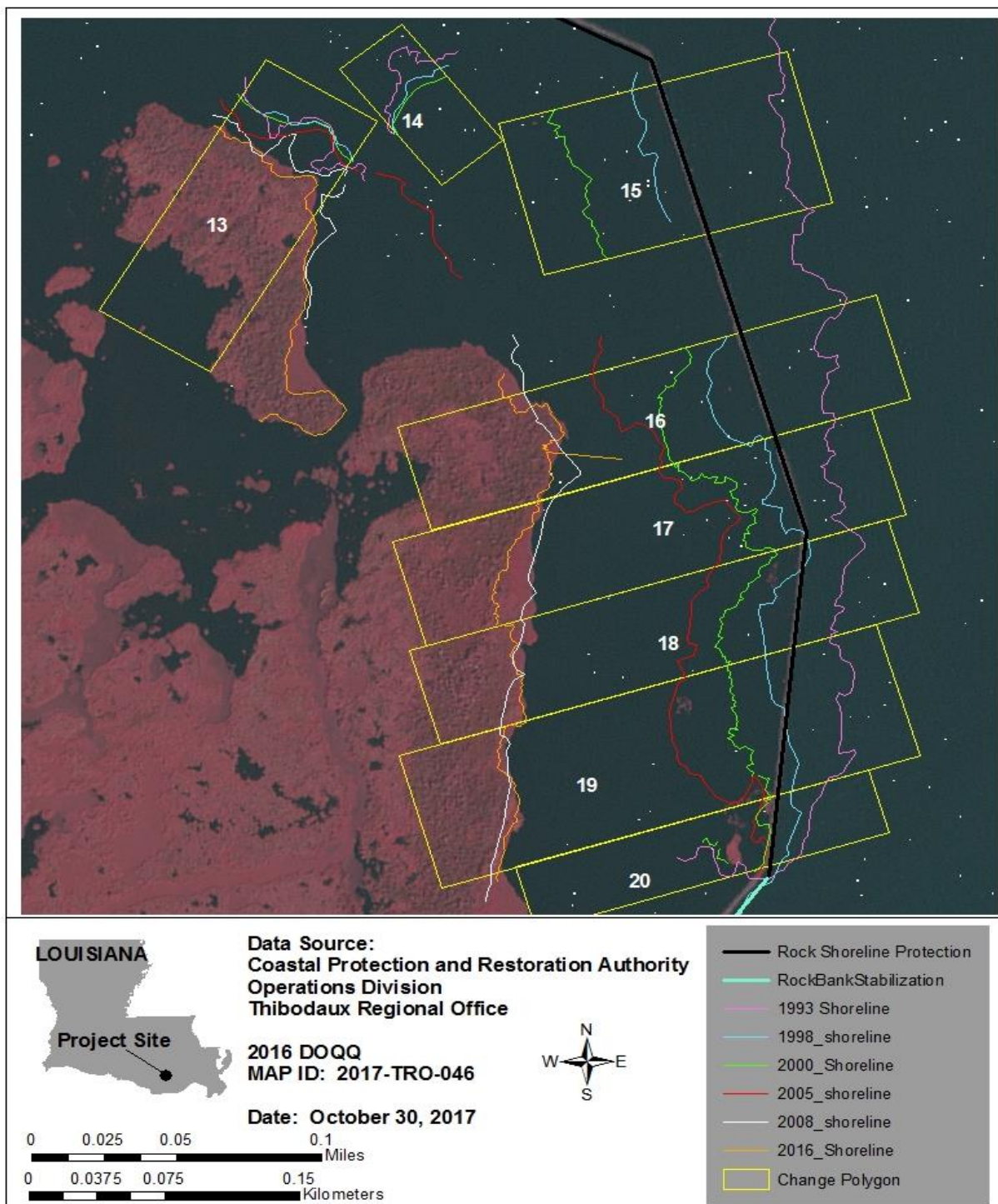


Figure 26. Typical shoreline data collection areas showing the location of 1993, 1998, 2000, 2005, 2008, and 2016 shoreline segments for BA-02.

In order to calculate the change rate per year for a given span of years, the land area inside the standardized polygon created for each shoreline segment was first determined for each survey year. The difference between the areas inside the polygon for a given span of years represented the change in the area in (m²).

Example:

$$\text{Year 2000 Area (m}^2\text{)} - \text{Year 2016 Area (m}^2\text{)} = \text{Area Change}$$

Next, an average change rate was calculated by taking the area change inside the shoreline segment polygon and dividing it by the shoreline segment length.

$$\text{Area Change (m}^2\text{)} \div \text{Shoreline Segment Length (m)} = \text{Avg Change Rate (m)}$$

Finally, the average change rate was divided by the number of days within the span of the two surveys being compared, and then multiplied by 365.25 days to determine the change rate per year. The 365.25 day count was used to make allowances for leap years. Also, the change rates for year spans were weighted, meaning these calculations only involved the same 16 segments present throughout the entirety of monitoring.

$$(\text{Avg Change Rate (m)} \div \text{\# of Days between surveys}) \times 365.25 \text{ days} = \text{Change Rate/Year (m/yr}^{-1}\text{)}$$

Shoreline Change Results and Discussions

Results indicate that from 1993 through 1998 (pre-construction) all 21 shoreline segments remained intact. Utilizing loss rates for only those 16 segments which remained intact for the entirety of data collection, the average pre-construction shoreline change rate from 1993-1998 was -1.94 m/yr⁻¹ (figure 27). By 2016 (16 years post-construction) five of the 21 segments had either completely or partially eroded away to non-continuous broken marsh. Between 2000 and 2016 (post-construction) average shoreline change rate was -1.49 m/yr⁻¹ for the remaining 16 shoreline segments. Segments 14 and 15 disappeared between 2003 and 2005. Segment 2 experienced a reduction in shoreline loss based upon the 2008 survey, but by 2012 this segment eroded beyond the point of being a continuous shoreline and only broken marsh remained. Segment 3 was almost completely eroded away leaving heavily broken marsh in place of a continuous shoreline, and by 2008 segment 20 eroded beyond the change polygon used to calculate change rates. Of the 16 remaining shoreline segments in 2016, there was a post-construction reduction in the rate of erosion for segments 1, 10, 11, 12, and 16-20. Conversely, the post-construction erosion rate increased for segments 4-8, 13, and 21.

A comparison of change rates utilizing the same 16 shoreline segments with various survey date ranges (figure 28) illustrates when some of the more drastic shoreline changes occurred. The

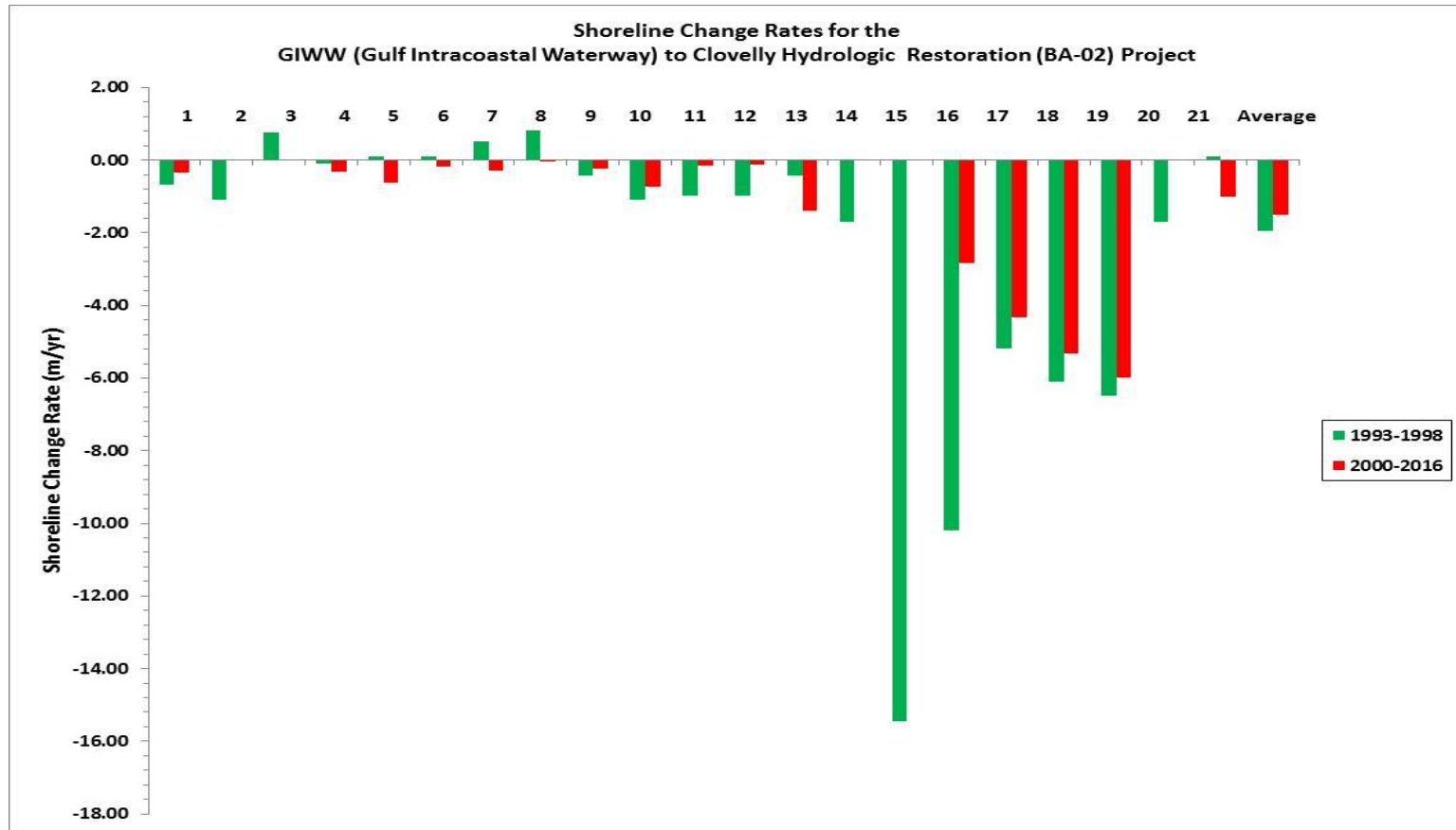


Figure 27. Shoreline change rates for each randomly selected shoreline segment pre- and post-construction, and the average shoreline change rate. Note: Construction ended October 31, 2000. Segments 2, 3, 14, 15, and 20 were not calculated into the “Average” change rate because there was no discernible continuous shoreline.

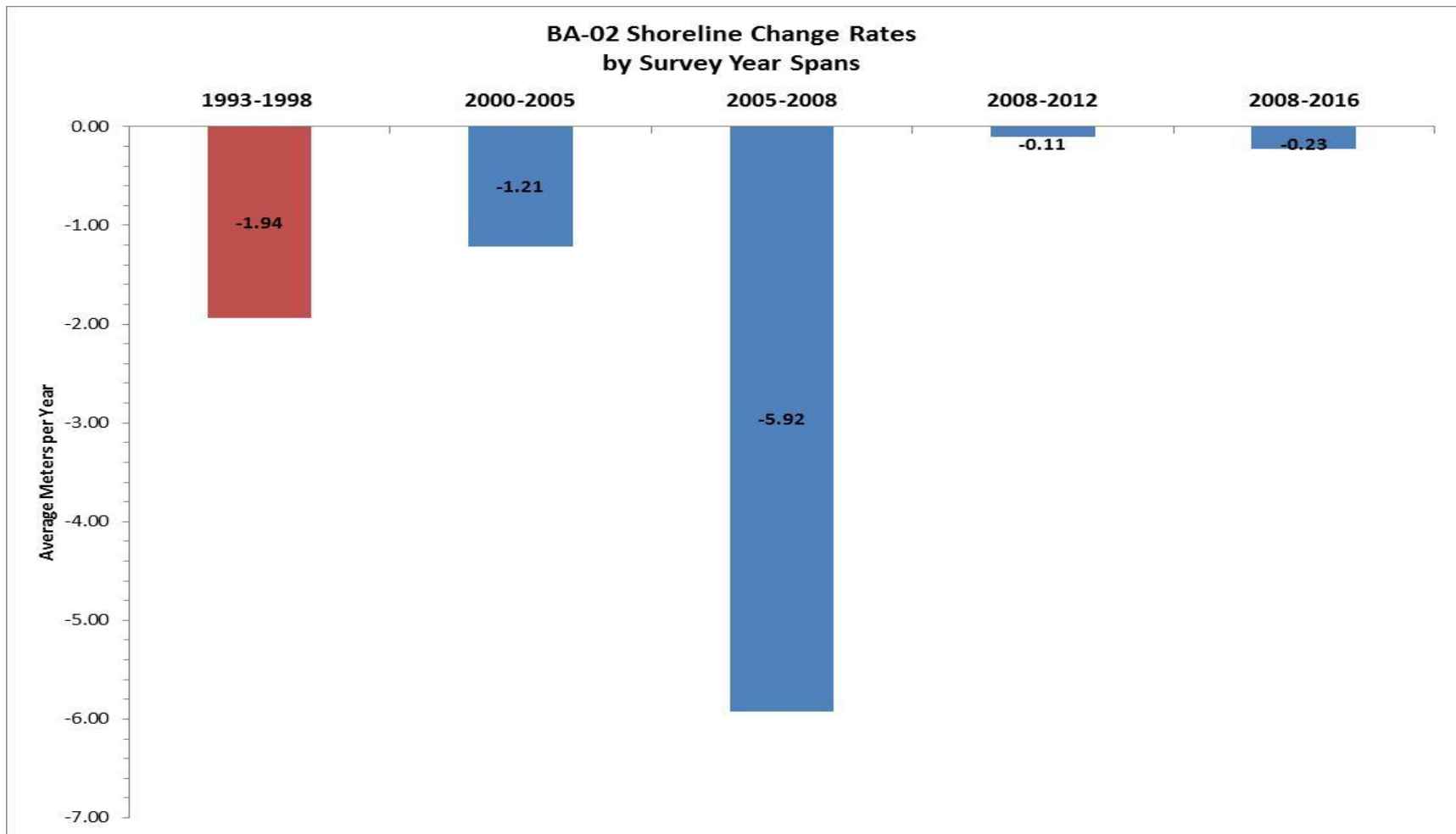


Figure 28. A comparison of average yearly shoreline change rates utilizing various survey year spans for BA-02.

greatest changes occurred between the 2005 and 2008 surveys when the shoreline loss reached an average yearly rate of -5.92 m/yr^{-1} . In this time frame some of the most powerful tropical systems impacted the area including hurricanes Cindy, Katrina, Rita, Gustav, and Ike. Conversely, the lowest rate of change (-0.11 m/yr^{-1}) occurred between the 2008 and 2012 surveys. It is noteworthy that the rate of erosion was reduced after construction between the years 2000 and 2005. Though the 2008-2016 post-construction erosion rate is slightly higher than the last survey in 2012, it is still substantially less than in pre-construction. Several factors may have contributed to the increase or decrease of erosion rates, which include, but are not limited to, orientation along the shoreline, proximity to the rock shoreline protection structure, the effects of powerful storms, and the increased amount of open water between the structure and the existing shoreline, causing more frequent and larger wave action.

Submerged Aquatic Vegetation (SAV)

SAV data were collected during the fall of 1996, during the fall and spring of 1999 and 2000, and during the fall of 2002 and 2005. Initially, fifteen (15) ponds were selected for data collection; however, three (3) ponds in the northern portion of the project were dropped due to land rights issues, as well as five (5) reference area ponds, leaving seven (7) ponds for SAV sampling (Appendix C; figure 2). Each pond was sampled at random points along transects using the rake method (Chabreck and Hoffpauir 1962; Nyman and Chabreck 1996). The number of random points and transects was determined based upon the size and configuration of the pond. Frequency of SAV occurrence was determined for each area from the number of points at which SAV occurred and the total number of points sampled.

Data Analysis Methods for SAV:

Field data were entered into an electronic format where CPRA/Operations personnel followed QA/QC procedures prior to data analysis as stated in Folse et al. (2012, revised 2014).

SAV Results and Discussions

Submerged aquatic vegetation sampling has occurred seven (7) times in five (5) years. The spring sampling events of 1999 and 2000 showed fewer empty pulls than in the fall (figure 29). The larger difference was between the spring and fall 2000 sampling periods, when the drought may have had an impact on SAV abundance. Salinity was on the rise during the spring sampling period; however, the maximum salinity was recorded after the spring period, which may have affected the vegetation. The 2002 and 2005 results may be attributed to the passing of Hurricanes Lili (2002) and Katrina and Rita (2005).

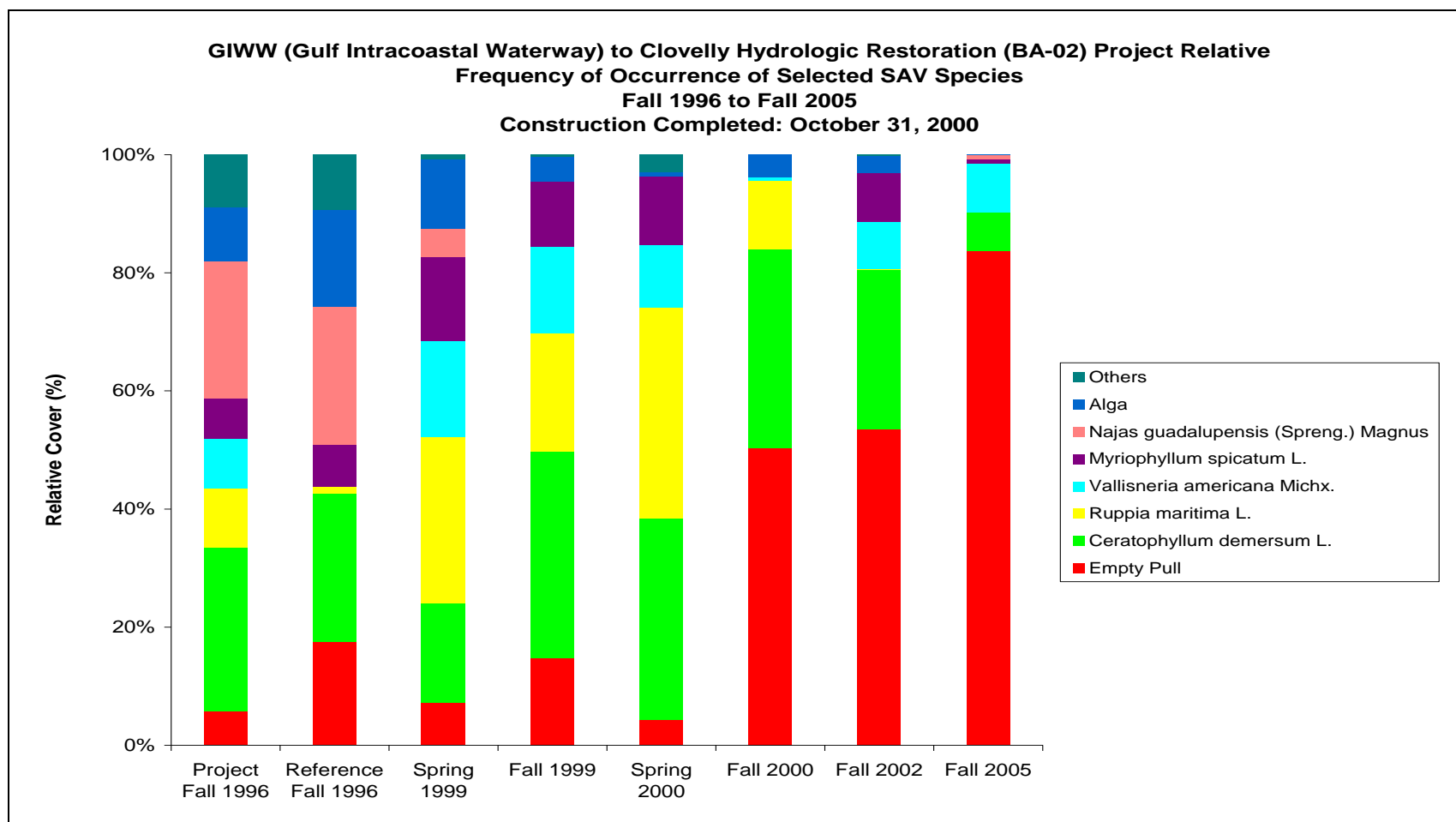


Figure 39. Relative frequency of occurrence of SAV species inside the BA-02 project area.

Conclusions

a. Project Effectiveness

The GIWW to Clovelly Hydrologic Restoration (BA-02) project, whose objectives are to restore natural hydrologic conditions and reduce shoreline erosion, has met with some success. Based upon the most recent analyses of water level and salinity data, additional Land-Water analyses, mean cover and species composition data, soil properties data, and the 2016 shoreline analysis, the project continues to sustain itself as a healthy intermediate marsh.

1. Increase or maintain marsh to open water ratio.

Based upon land-water analyses for data collected from 2002 through 2016, the project and reference areas have continued to transition from land to water at similar rates. Land to water conversion rates increased substantially between 2005 and 2008 due to impacts from large tropical systems such as hurricanes Katrina and Gustav. Both areas experienced little to no land loss after 2008 due to a lull in major hurricane activity, and even recovered land acreage. Though land loss continues, the project area has experienced a substantial post-construction reduction in land loss rates.

2. Decrease salinity variability in the project area, and 5. Promote greater freshwater retention and utilization in the project area.

The project area has maintained itself as a healthy intermediate marsh with lower and less variable salinities than those areas outside of its boundaries. Throughout the 20-year project life salinities inside the project boundary have remained below 3.0 ppt. Mean salinities in the southernmost areas of the project were higher than the central or northern areas, most likely due to greater tidal influences. Based upon all available concurrent data, the project area had consistently lower salinity ranges when compared to CRMS-*Wetlands* reference sites outside of the project boundary.

3. Decrease the water level variability in the project area, and 5. Promote greater freshwater retention and utilization in the project area.

Water level analysis showed that the project area has maintained similar water levels throughout the period of record. Water level patterns inside the project area were similar from year to year to those outside of the project area. The exception was the northernmost project area, which had the smallest water level range, likely because it was not as influenced by tidal activity as the areas to the south. The project did have an overall effect on water level ranges when compared to CRMS-*Wetland* stations. The water level range inside the project area was 0.81 feet lower overall than the CRMS-*Wetlands* reference areas. Where mean marsh

elevations at each project-specific site were compared to their mean water elevations, none of the sites were continuously flooded.

The Hydrologic Index (HI) for CRMS0190-H01 inside the project area was equal to or higher than all other CRMS-*Wetlands* sites within the same marsh type within the Barataria basin as well as all intermediate marsh types throughout the Louisiana Coastal Zone. The HI was higher than all CRMS-*Wetlands* sites within all marsh types throughout the Louisiana coastal zone. The exception was in 2016 where the HI score was the lowest. The high HI scores indicate that the project area hydrologic conditions have provided a healthy environment for intermediate marsh vegetation to thrive.

4. **Increase or maintain the relative abundance of intermediate marsh plants.** The project has been successful in meeting the goal to increase or maintain the relative abundance of intermediate marsh plants. Project specific data has shown that despite a downward trend in the mean cover of dominant intermediate vegetation species following construction in 2000, the mean cover values rebounded in 2012 and 2016 to levels higher than those in 1996 during pre-construction. The Floristic Quality Index and the project specific mean cover data followed a similar trend, with the exception of 2008 (Hurricane Gustav) in which mean cover of the dominant species increased but the FQI decreased. The VV within the BA-02 project area decreased following construction where it dropped to less than half of its pre-construction metric by 2012. The decrease began in 2005 following hurricane Katrina, however it rebounded in 2016. Species diversity varied throughout the years. The highest diversity occurred during pre-construction, yet despite the powerful hurricanes during post-construction, project area diversity rebounded

FQI for the project CRMS-*Wetlands* site (CRMS0190) experienced an overall downward trend between 2006 and 2017 with some variability in between. Despite the trend, the FQI for all years fell within the good and fair categories for wetland quality compared to all other CRMS-*Wetlands* sites within the same vegetation type and hydrologic basin. With the exception of 2011, CRMS0190 FQI scores were within the good to fair categories when compared to CRMS-*Wetlands* sites of all vegetation types within the Barataria basin from 2006 to 2017. With the exception of 2011, CRMS0190 FQI scores were higher or equal to all CRMS-*Wetlands* sites within the Louisiana coastal zone. The VV scores for this site followed the same trend as the FQI scores except in year 2017.

Mean cover of *S. patens*, as well as FQI fluctuated throughout the years for the CRMS-*Wetlands* reference stations.

- 6. Reduce shoreline erosion through shoreline stabilization.** The goal to reduce shoreline erosion through shoreline stabilization has had overall positive results. Shoreline erosion continued through 2016. There was variation in the loss rates through the years but despite this, the post-construction loss rate was 0.45 m/yr^{-1} less than in pre-construction. There were initially 21 shoreline segments from which to collect data. Of those segments, 16 remained from which data collection was possible. Five of the shoreline segments fragmented to the point of being non-continuous.

Shoreline loss peaked between the 2005 and 2008 surveys when the area was impacted by powerful hurricanes; however, rates markedly decreased between 2008 and 2012, and though they increase slightly in 2016, they were markedly lower than pre-construction rates. The highest average erosion rates occurred along the easternmost segments which extend out into Bay L'Ours. The lowest rates occurred along the interior shorelines behind the rock shoreline protection structure.

- 7. Increase or maintain the relative abundance of submerged aquatic vegetation (SAV).** Based upon the CRMS-*Wetlands* review, SAV data collection was discontinued after 2005. Results to meet the project goal were inconclusive. The SAV in the project area responded to changes in salinity. As salinity increased, the total number of species and the relative frequency of occurrence of species decreased.

b. Lessons Learned

Under the current design criteria for CWPPRA projects, most Hydrologic Restoration (HR) projects are designed with the aid of a hydrodynamic model to actively manage coastal restoration projects. Since the GIWW to Clovelly Hydrologic Restoration (BA-02) project was implemented in the early stages of the CWPPRA program, hydrologic modeling was not performed during the design phase. Evaluation of the initial post-construction data did not result in a conclusive determination regarding project effectiveness; therefore, a post construction hydrodynamic model was developed on a subset of project features to determine if the constructed features were providing the anticipated reduction in salinity and tidal exchange, and to assess whether the project features required design modifications. “The results of the model illustrated that the constructed features reduced salinity in the project area on the order of 3 to 4 ppt on average with no modifications. Modifications to the largest structure along Clovelly Canal revealed that an additional 2 to 3 ppt reduction in salinity levels could be attained by reducing the size of the barge bay opening” (Meselhe et al. 2006). From the limited modeling effort completed on this project, we have learned that biological data collection alone does not always provide the conclusive results

in determining project effectiveness, and that biological data collection along with hydrodynamic modeling can be utilized to analyze goals and objectives of HR projects.

Land rights for both the project area and reference area need to be acquired prior to the construction of the project in areas that represent the project area. This was one of the first projects; land rights are currently acquired much earlier in the process than they were at the start of this project. Land rights agreements should be reviewed periodically for expiration dates at some point after construction to ensure that enough time remains on the agreement to complete the project as intended.

Data collection stations need to be located in the proper areas both within the project area and—more importantly—in the reference area. Without an appropriate reference area, it is much more difficult to determine the effectiveness of the project features.

Data collection stations should not be inactivated until substitute stations are established and active. As with the CRMS-*Wetlands* project, the anticipated timeline for station construction and activation was delayed due to several external factors. Project-specific stations should have remained active until the CRMS-*Wetlands* were active so there would be no data gaps.

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Appendix A

Inspection Photos
And
O&M Budget Projections



Photo No.1 – View of navigational aid and rock weir with barge bay across Clovelly Canal at Little Lake.



Photo No.2 – View of rock weir along Little Lake on the north side of Structure 14A.



Photo No.3 – View of rock weir and navigational aid along shoreline of Little Lake on south side of Structure 14A.



Photo No.4 – View of rock weir to bank tie-in on the south side of Structure No.14A.



Photo No.5 – View of rock weir with boat bay (Structure 7) from Little Lake.



Photo No.6- View of the rock weir to shore tie-in on the north side of Structure No.7.



Photo No.7 – View of the rock weir to shore tie-in on the south side of Structure No.7.



Photo No.8 – View of the small rock weir (Structure 8) along a channel from the interior marsh.



Photo No.9 – View of the northern end of the rock plug (Structure 4A and 4B) along the shoreline of Bay L' Ours.



Photo No.10 – View of the rock plug (Structures 4A and 4B) along the shoreline of Bay L' Ours.



Photo No. 11 – View of the rock closure structure between Structures (4A/4B) and the rock weir with boat bay (Structure 4).



Photo No.12 – View of the warning sign at the fish dip along the rock closure structure between Structures 4A/4B and 4.



Photo No.13 – View of the warning sign at the fish dip along the rock closure structure between Structures 4A/4B and 4.



Photo No.14 – View of the rock weir with boat bay at Structure 4 from Bay L’ Ours.



Photo No.15 – View of the southern end of Structure 4 and new dike under construction.



Photo No.16 – View of rock weir with boat bay at Structure 2 from Bay L’ Ours.



Photo No. 17 – View of the northern side of the rock weir with boat bay at Structure 2.



Photo No. 18 – View of the southern side of the rock weir with boat bay at Structure 2.



Photo No. 19 – View of the shoreline protection (lake rim) between Structure 2 and Breton canal.



Photo No. 20 – View of the shoreline protection (lake rim) between Structure 2 and Breton canal.



Photo No. 21 – View of the shoreline protection (lake rim) between Structure 2 and Breton canal.



Photo No. 22 – View of the shoreline protection (lake rim) between Structure 2 and Breton Canal.



Photo No. 23 – View of the shoreline protection (lake rim) along Breton Canal.



Photo No. 24 – View of the shoreline protection (lake rim) along Breton Canal.



Photo No. 25 – View of the north termination of the shoreline protection (lake rim) along Breton Canal.



Photo No.26 – View of the variable crest weir (Structure 35) located along an existing location canal off of Breton Canal.



Photo No.27 – View of boom system for moving stop logs and the interior marsh behind Structure 35.



Photo No.28 – View of the sheet pile wall tie-in to bank on the north side of Structure 35.



Photo No.29 – View of the stop log bay and sheet pile wall tie-in to bank on the south side of Structure 35.



Structure No.30 – View of breach in the north bank of Breton Canal near the location canal where Structure 35 is located.



Photo No.31 – View of the breach repair performed in 2012 along the north bank of Breton Canal.



Photo No.32 – View of breach repair along north bank of second location canal from Bay L' Ours.



Photo No.33 – View of breach repair along south bank of second location canal from Bay L' Ours.



Photo No.34 – View of rock plug with flap-gated culvert (Structure 91) along an interior channel.



Photo No. 35 – View of rock plug (Structure 90) along interior channel near southern boundary of project.



Photo No.36 – View of timber pile dolphins and signs at the entrance to the barge bay at Structure 1.



Photo No.37 – View of west side bank tie-in of rock weir at Structure 1.



Photo No.38 – View of east side bank tie-in of rock weir at Structure 1.



Photo No.39 – View of rock plug and warning sign at Structure 43.

GIWW TO CLOVELLY, PHASES 1 & 2 / BA-02 / PPL1
Three-Year Operations & Maintenance Budgets 07/01/2018 - 06/30/21

<u>Project Manager</u>	<u>O & M Manager</u>	<u>Federal Sponsor</u>	<u>Prepared By</u>
	A. Ledet	NRCS	B. Bablin
	2018/2019	2019/2020	2020/2021
Maintenance Inspection			
Nav. Aid Inspection/Maint.			
Structure Operation			
State Administration	\$ 10,000.00	\$ -	\$ -
Federal Administration	\$ -	\$ -	
Maintenance/Rehabilitation			

18/19 Description: Project Close-out. Remaining Construction Funds to be paid.

E&D	\$ -
Construction	\$ 447,652.00
Construction Oversight	
Sub Total - Maint. And Rehab.	\$ 447,652.00

19/20 Description:

E&D	\$ -
Construction	\$ -
Construction Oversight	\$ -
Sub Total - Maint. And Rehab.	\$ -

20/21 Description:

E&D	\$ -
Construction	\$ -
Construction Oversight	\$ -
Sub Total - Maint. And Rehab.	\$ -

	2018/2019	2019/2020	2020/2021
Total O&M Budgets	\$ 457,652.00	\$ -	\$ -
Total O&M Budget 2018 through 2021			\$ 457,652.00
Unexpended O&M Budget			\$ 268,544.00
Remaining O&M Budget (Projected)			\$ (189,108.00)

Unexpended budget includes a deduction for NRCS M IPR in the amount of \$88,458

WORKSHEET

Project: BA-02 GIWW to Clovelly Hydrologic Restoration Ph. 1 &2

FY 18/19 –

CPRA Administration	\$	10,000
(2016 Maintenance Project)		
Structure Operations:	\$	
Maintenance:	\$	447,651.50
E&D:	\$	0
Construction:	\$	447,651.50
Construction Oversight:	\$	
General Maintenance:	\$	

Operation and Maintenance Assumptions:

Structure Operations: water control structure operated twice annually for a total of \$5,000 per operation. (2)(\$5,000) = **\$10,000**

General Maintenance: Water control structure, navigation aids repair. Construction: **\$4,000**.

2014 Maintenance Project – Composite Rock Dike along shoreline between Structures 2 and 4.
Below is the estimated project cost this maintenance project:

Construction Cost:

DQSI Bid: \$1,457,850.16 - (\$447,651.50 – Not yet paid)

CPRA Administration: \$10,000 Project Close-out

2018-2021 Accounting

Current O&M Funding: (CSA Amendment No.4)	\$5,215,306
State Expenditures (LaGov):	\$4,860,306
Federal Expenditures MIPR:	<u>\$ 86,456</u>
Unexpended Funds:	\$ 268,544

Appendix B
Habitat Analysis Maps
and
Land-Water Maps



**GIWW (Gulf Intracoastal Waterway) to Clovelly
Hydrologic Restoration (BA-02)
Coastal Wetlands Planning, Protection and Restoration Act
1993 Habitat Analysis**

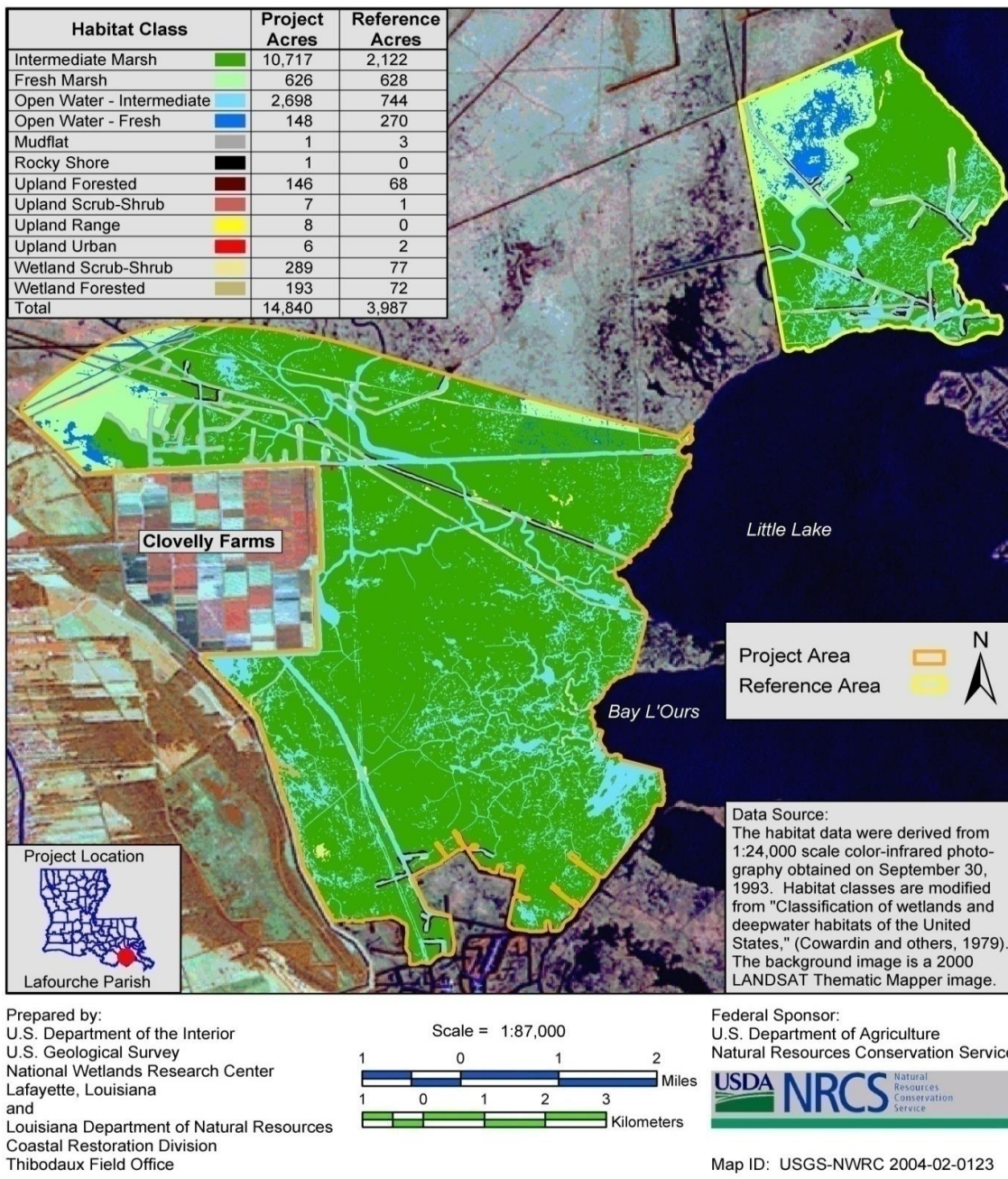
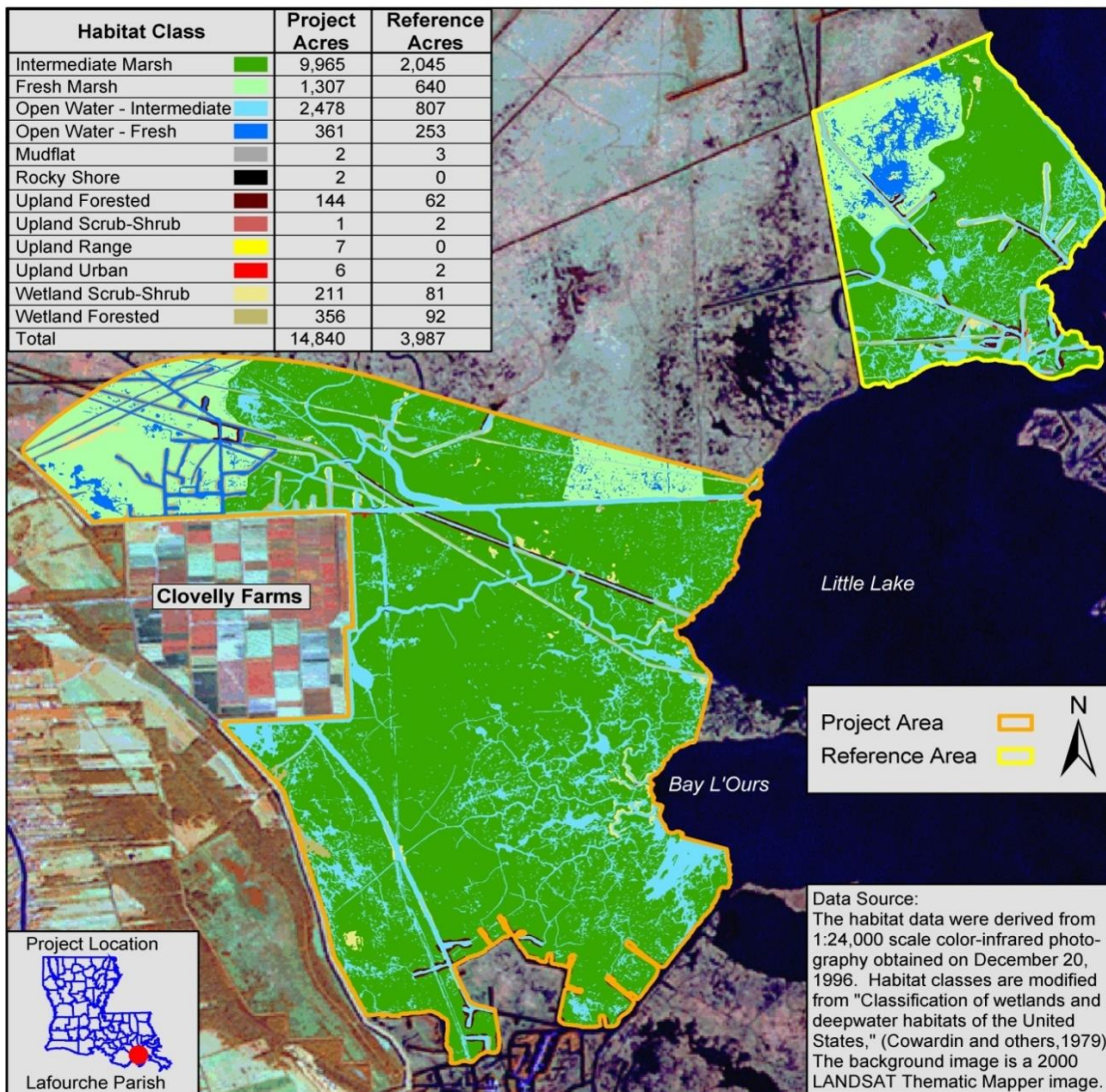


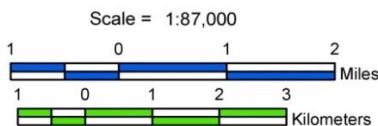
Figure 1. 1993 Habitat Analysis Map for the BA-02 Project and reference areas.



**GIWW (Gulf Intracoastal Waterway) to Clovelly
Hydrologic Restoration (BA-02)**
Coastal Wetlands Planning, Protection and Restoration Act
1996 Habitat Analysis



Prepared by:
U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center
Lafayette, Louisiana
and
Louisiana Department of Natural Resources
Coastal Restoration Division
Thibodaux Field Office



Federal Sponsor:
U.S. Department of Agriculture
Natural Resources Conservation Service

Map ID: USGS-NWRC 2004-02-0196

Figure 2. 1996 habitat analysis map for the BA-02 project and reference areas.



**GIWW (Gulf Intracoastal Waterway) to Clovelly
Hydrologic Restoration (BA-02)**
Coastal Wetlands Planning, Protection and Restoration Act
2002 Habitat Analysis

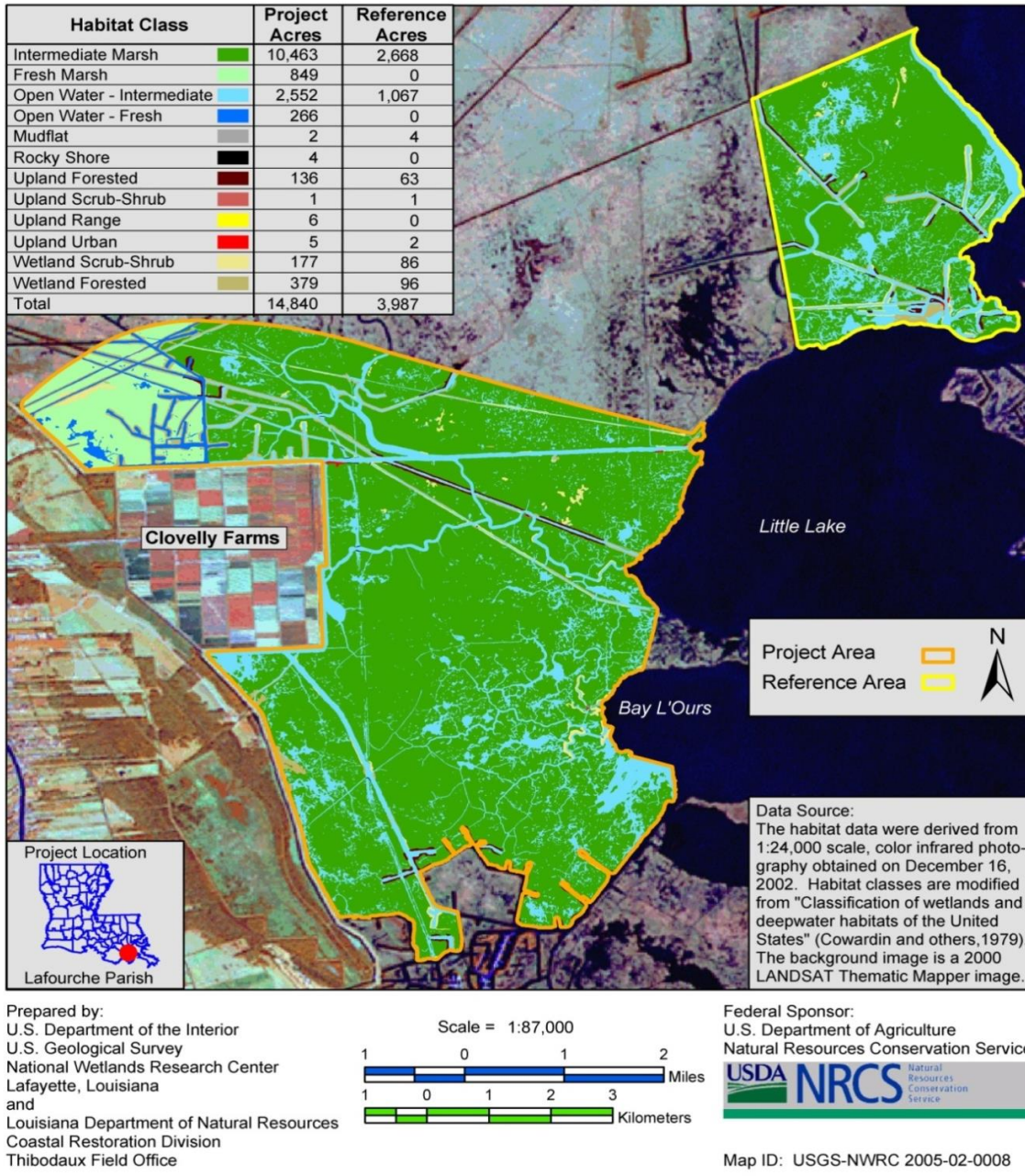


Figure 3. 2002 habitat analysis map for the BA-02 project and reference areas.



**GIWW (Gulf Intracoastal Waterway) to
Clovelly Hydrologic Restoration (BA-02)**
Coastal Wetlands Planning, Protection and Restoration Act
2005 Land-Water Classification

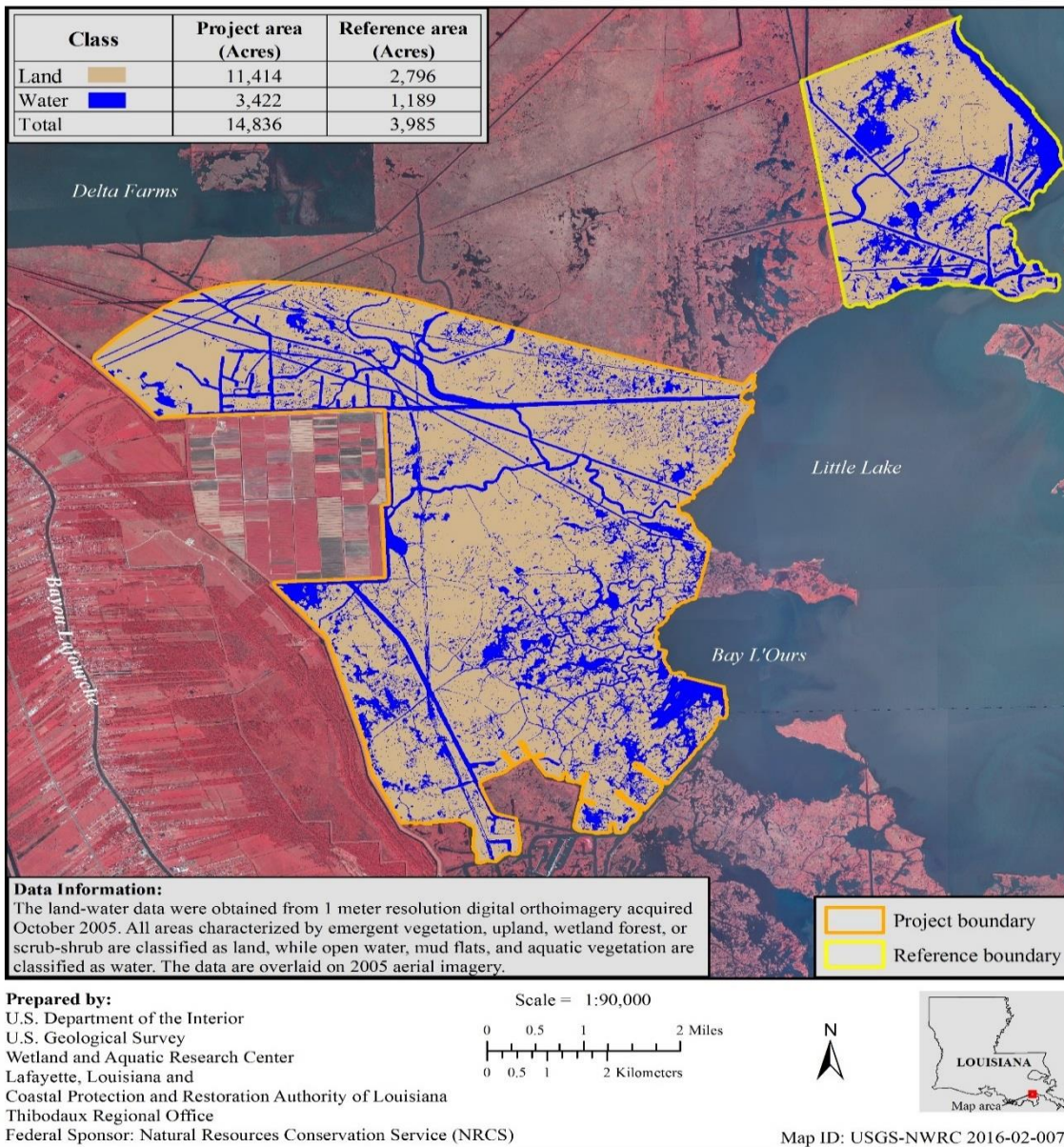
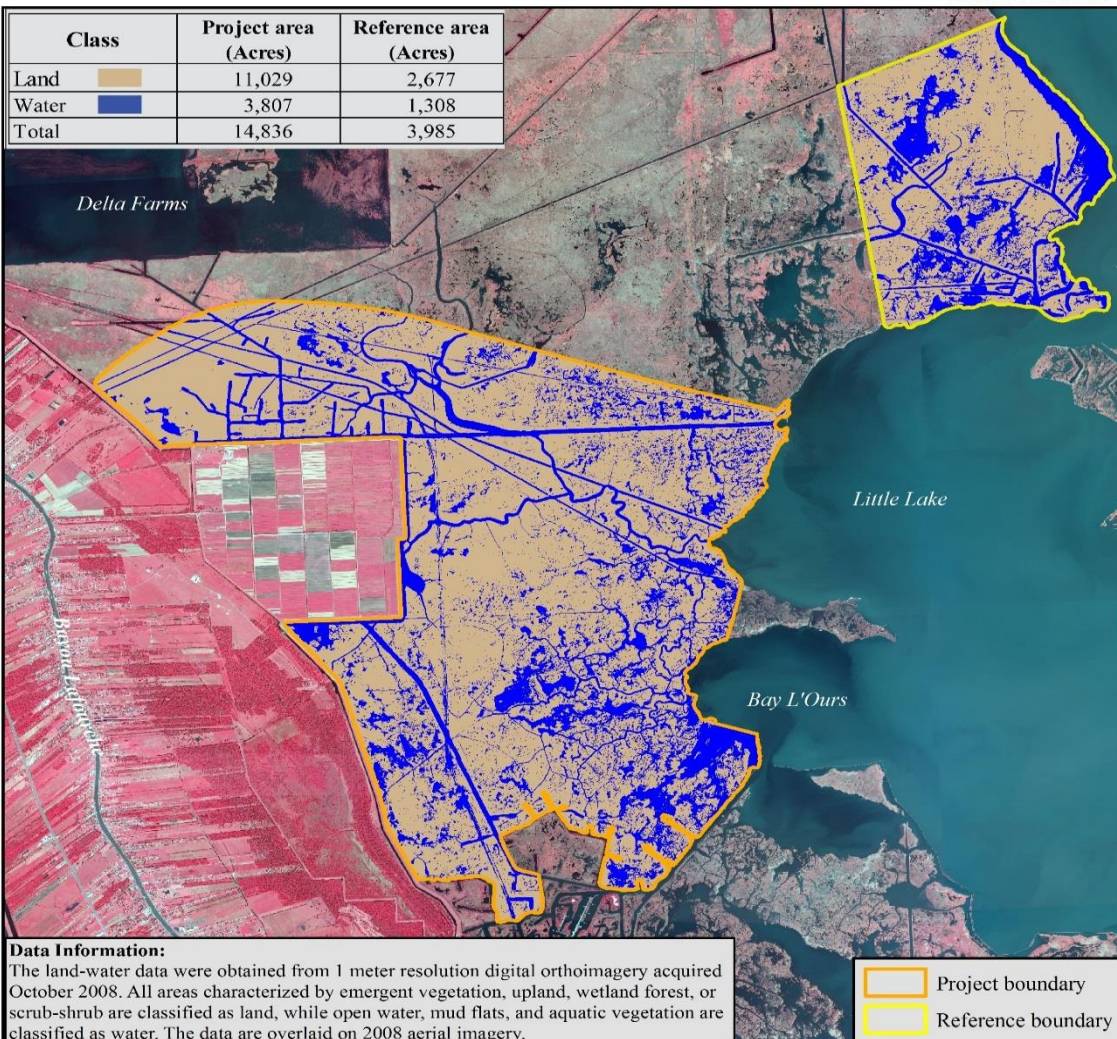


Figure 4. 2005 Land-Water Map for the BA-02 project and reference areas.





**GIWW (Gulf Intracoastal Waterway) to
Clovelly Hydrologic Restoration (BA-02)**
Coastal Wetlands Planning, Protection and Restoration Act
2008 Land-Water Classification



Prepared by:
 U.S. Department of the Interior
 U.S. Geological Survey
 Wetland and Aquatic Research Center
 Lafayette, Louisiana and
 Coastal Protection and Restoration Authority of Louisiana
 Thibodaux Regional Office
 Federal Sponsor: Natural Resources Conservation Service (NRCS)

Scale = 1:90,000
 0 0.5 1 2 Miles
 0 0.5 1 2 Kilometers



Map ID: USGS-NWRC 2016-02-0080

Figure 5. 2008 Land-Water map of the BA-02 project and reference areas.

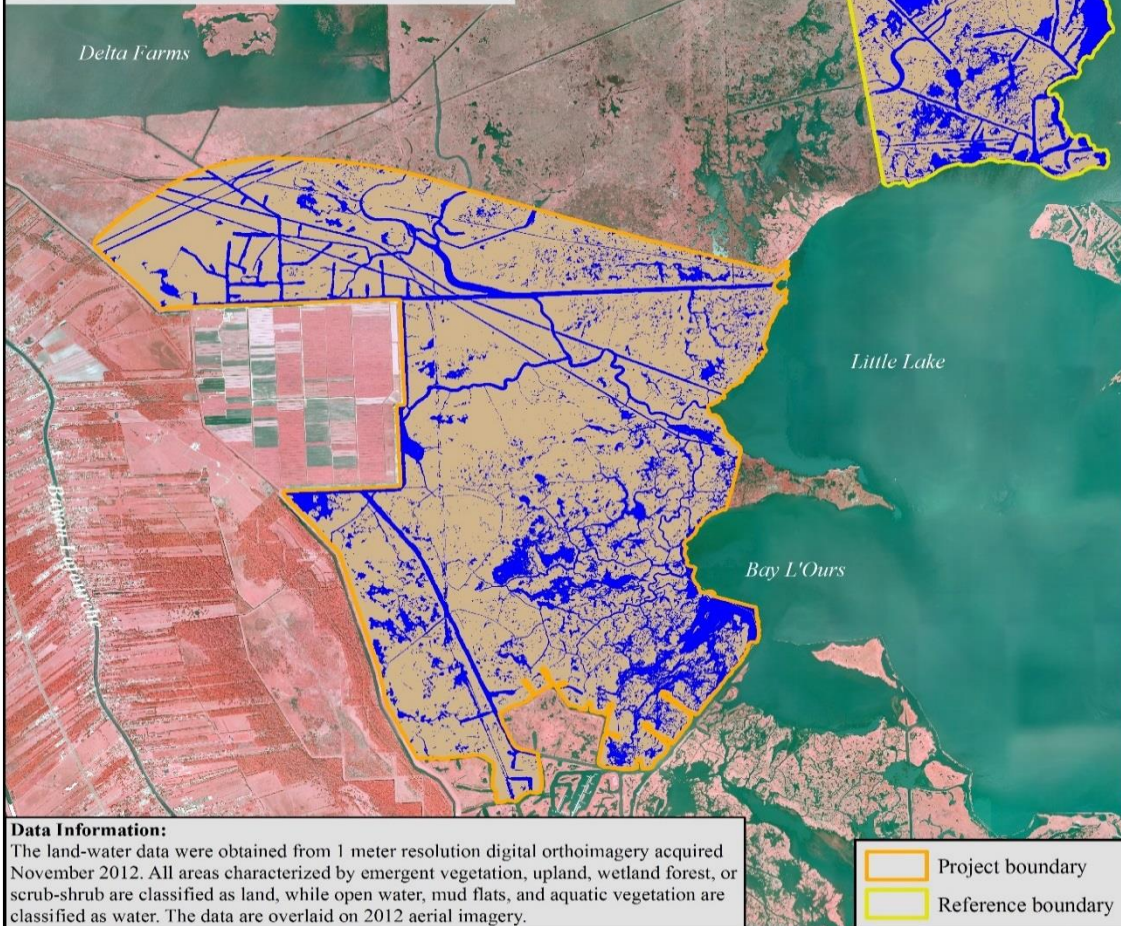




**GIWW (Gulf Intracoastal Waterway) to
Clovelly Hydrologic Restoration (BA-02)**
Coastal Wetlands Planning, Protection and Restoration Act
2012 Land-Water Classification



Class	Project area (Acres)	Reference area (Acres)
Land	11,654	2,780
Water	3,182	1,205
Total	14,836	3,985



Prepared by:
U.S. Department of the Interior
U.S. Geological Survey
Wetland and Aquatic Research Center
Lafayette, Louisiana and
Coastal Protection and Restoration Authority of Louisiana
Thibodaux Regional Office
Federal Sponsor: Natural Resources Conservation Service (NRCS)

Scale = 1:90,000
0 0.5 1 2 Miles
0 0.5 1 2 Kilometers



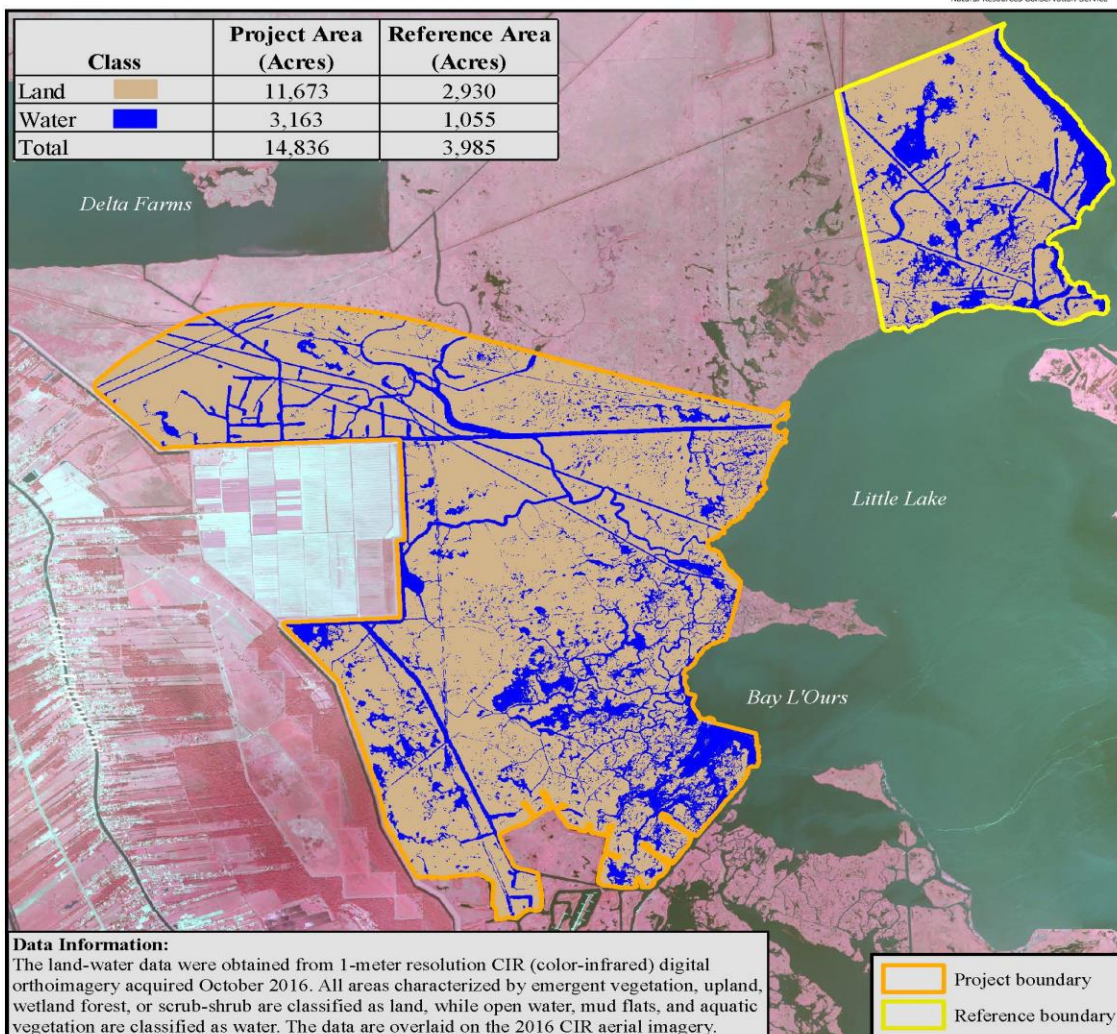
Map ID: USGS-NWRC 2016-02-0081

Figure 6. 2012 Land-Water map of the BA-02 project and reference areas.





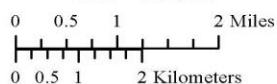
**GIWW (Gulf Intracoastal Waterway) to
Clovelly Hydrologic Restoration (BA-02)**
Coastal Wetlands Planning, Protection and Restoration Act
2016 Land-Water Classification



Prepared by:

U.S. Department of the Interior
U.S. Geological Survey
Wetland and Aquatic Research Center
Lafayette, Louisiana and
Coastal Protection and Restoration Authority of Louisiana
Thibodaux Regional Office
Federal Sponsor: Natural Resources Conservation Service (NRCS)

Scale = 1:90,000



Map ID: 10.5066/F7TB165M

Figure 7. 2016 Land-Water map of the BA-02 project and reference areas.



Appendix C

Discrete Hydographic Project Stations Map

and

Project SAV Ponds Location Map

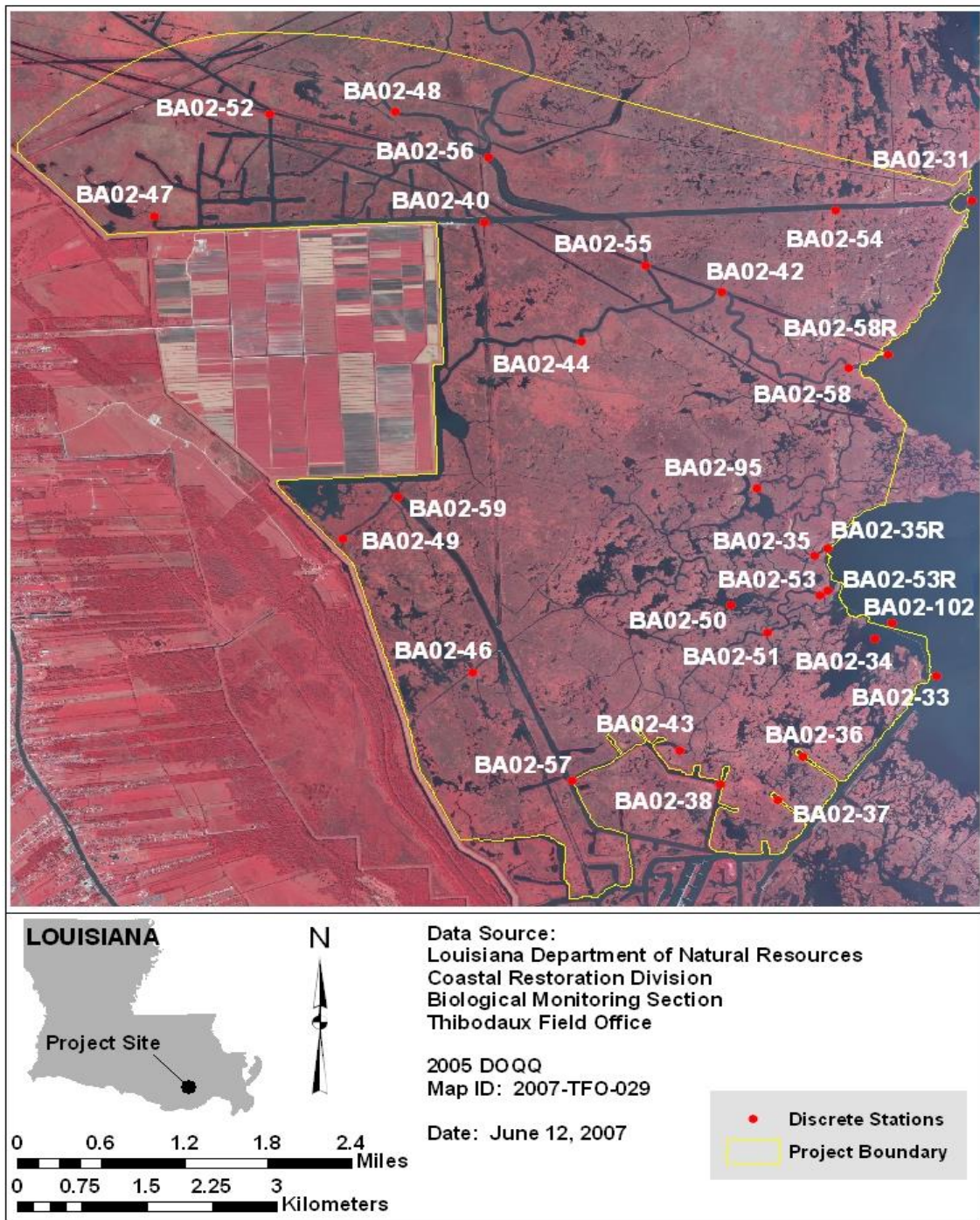


Figure 1. Project discrete water level and salinity station map for the BA-02 project.

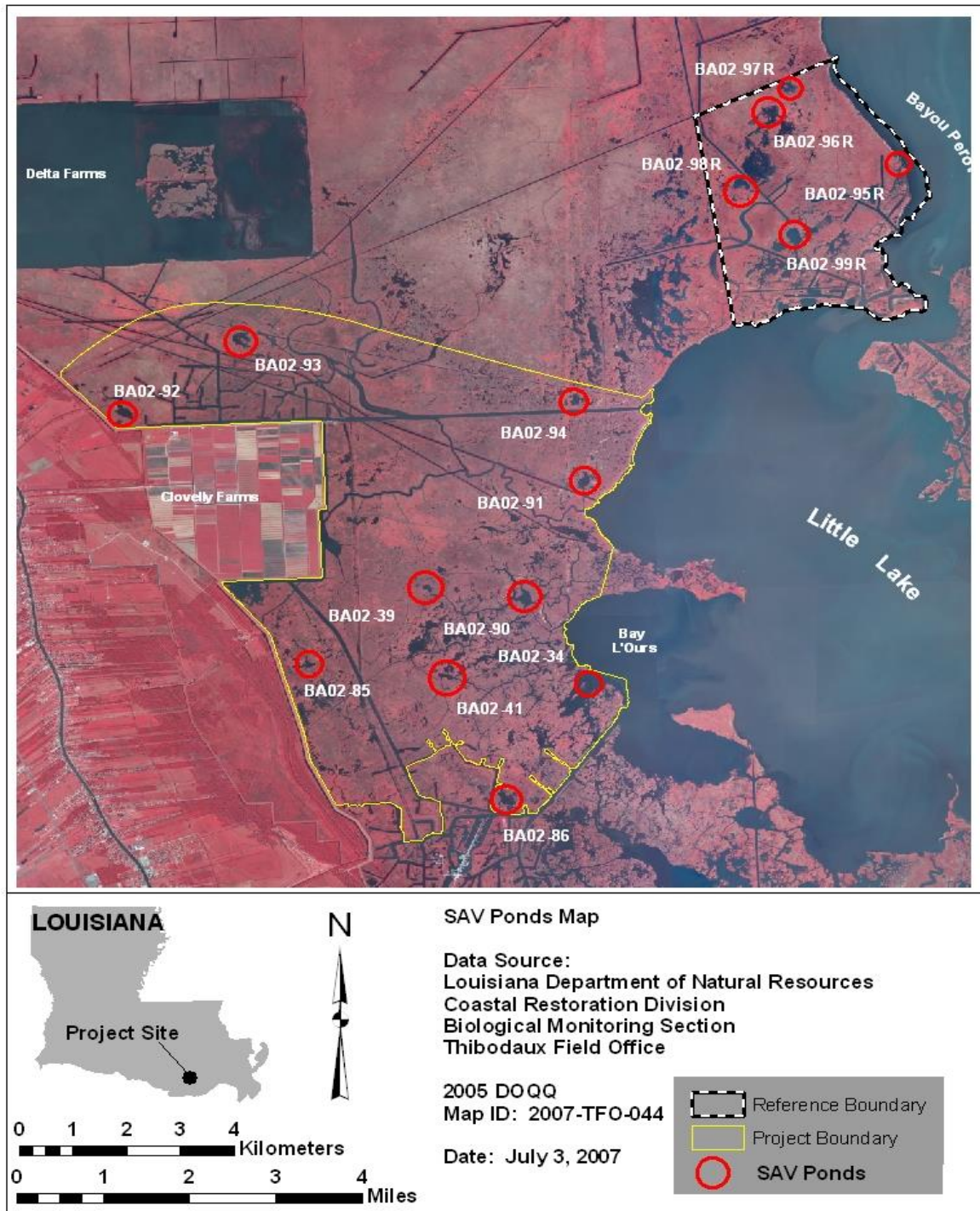


Figure 2. Location map of SAV ponds inside the BA-02 project and reference areas.

Appendix D

Coefficient of Conservatism (CC) Scores

Coefficient of Conservatism (CC) scores for all flora species documented at the BA-02 project-specific vegetation stations as well as the BA-02 project and reference CRMS stations.

Scientific Name	CC Score
<i>Acer rubrum</i> L.	7
<i>Acer rubrum</i> L. var. <i>drummondii</i> (Hook. & Arn. ex Nutt.) Sarg.	7
<i>Agalinis heterophylla</i> (Nutt.) Small ex Britt.	6
<i>Agalinis purpurea</i> (L.) Pennell	6
<i>Alopecurus carolinianus</i> Walt.	1
<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	0
<i>Amaranthus australis</i> (Gray) Sauer	2
<i>Amaranthus cannabinus</i> (L.) Sauer	2
<i>Amaranthus</i> L.	2
<i>Amaranthus tuberculatus</i> (Moq.) Sauer	2
<i>Ammannia coccinea</i> Rottb.	4
<i>Ammannia latifolia</i> L.	4
<i>Andropogon glomeratus</i> (Walt.) B.S.P.	3
<i>Baccharis halimifolia</i> L.	4
<i>Bacopa monnieri</i> (L.) Pennell	5
Bare Ground	
<i>Bidens laevis</i> (L.) B.S.P.	3
<i>Ceratophyllum demersum</i> L.	
<i>Cladium mariscus</i> (L.) Pohl	8
<i>Cladium</i> P. Br.	8
<i>Crinum americanum</i> L.	8
<i>Cucumis</i> L.	
<i>Cuscuta indecora</i> Choisy	
<i>Cuscuta</i> L.	
<i>Cynanchum angustifolium</i> Pers.	6
<i>Cyperus bipartitus</i> Torr.	
<i>Cyperus distinctus</i> Steud.	
<i>Cyperus erythrorhizos</i> Muhl.	3
<i>Cyperus esculentus</i> L.	0
<i>Cyperus filicinus</i> Vahl	4
<i>Cyperus haspan</i> L.	5
<i>Cyperus</i> L.	
<i>Cyperus odoratus</i> L.	4
<i>Cyperus oxylepis</i> Nees ex Steud.	4
<i>Cyperus strigosus</i> L.	3
<i>Distichlis spicata</i> (L.) Greene	2
<i>Echinochloa walteri</i> (Pursh) Heller	5
<i>Eleocharis baldwinii</i> (Torr.) Chapman	5

Coefficient of Conservatism (CC) scores (continued)

<i>Eleocharis cellulosa</i> Torr.	7
<i>Eleocharis flavescens</i> (Poir.) Urban	6
<i>Eleocharis montana</i> (Kunth) Roemer & J.A. Schultes	5
<i>Eleocharis parvula</i> (Roemer & J.A. Schultes) Link ex Bluff	3
<i>Eleocharis</i> R. Br.	
<i>Eriochloa contracta</i> A.S. Hitchc.	2
<i>Eupatorium capillifolium</i> (Lam.) Small	1
<i>Fimbristylis</i> Vahl	
<i>Galium</i> L.	2
<i>Galium tinctorium</i> L.	2
<i>Hydrocotyle bonariensis</i> Comm. ex Lam.	4
<i>Hydrocotyle umbellata</i> L.	3
<i>Hypericum</i> L.	
<i>Ipomoea sagittata</i> Poir.	8
<i>Iris</i> L.	
<i>Iva frutescens</i> L.	4
<i>Juncus roemerianus</i> Scheele	9
<i>Kosteletzkya virginica</i> (L.) K. Presl ex Gray	7
<i>Ludwigia octovalvis</i> (Jacq.) Raven	3
<i>Lythrum</i> L.	5
<i>Lythrum lineare</i> L.	5
<i>Mikania scandens</i> (L.) Willd.	3
<i>Mitreola petiolata</i> (J.F. Gmel.) Torr. & Gray	5
<i>Morella cerifera</i> (L.) Small	6
<i>Osmunda regalis</i> L.	8
<i>Panicum hemitomon</i> J.A. Schultes	10
<i>Panicum</i> L.	
<i>Pennisetum glaucum</i> (L.) R. Br.	0
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	6
<i>Phyla lanceolata</i> (Michx.) Greene	3
<i>Phyla nodiflora</i> (L.) Greene	4
<i>Pluchea camphorata</i> (L.) DC.	2
<i>Pluchea odorata</i> (L.) Cass.	2
<i>Pluchea odorata</i> (L.) Cass. var. <i>odorata</i>	2
<i>Polygonum hydropiperoides</i> Michx.	4
<i>Polygonum punctatum</i> Ell.	5
<i>Rhynchospora colorata</i> (L.) H. Pfeiffer	6
<i>Rumex obovatus</i> Danser	
<i>Sabatia calycina</i> (Lam.) Heller	6
<i>Sabatia stellaris</i> Pursh	6

Coefficient of Conservatism (CC) scores (continued)

<i>Sacciolepis striata</i> (L.) Nash	6
<i>Sagittaria lancifolia</i> L.	6
<i>Salvinia minima</i> Baker	
<i>Schoenoplectus</i> (Reichenb.) Palla	7
<i>Schoenoplectus americanus</i> (Pers.) Volk. ex Schinz & R. Keller	8
<i>Schoenoplectus californicus</i> (C.A. Mey.) Palla	7
<i>Schoenoplectus pungens</i> (Vahl) Palla	7
<i>Schoenoplectus robustus</i> (Pursh) M.T. Strong	7
<i>Sesbania herbacea</i> (P. Mill.) McVaugh	2
<i>Setaria</i> Beauv.	
<i>Setaria faberi</i> Herrm.	0
<i>Setaria italica</i> (L.) Beauv.	0
<i>Setaria parviflora</i> (Poir.) Kerguelen	3
<i>Setaria pumila</i> (Poir.) Roemer & J.A. Schultes ssp. <i>pallidifusca</i> (Schumacher) B.K. Simon	0
<i>Solidago sempervirens</i> L.	4
<i>Spartina alterniflora</i> Loisel.	10
<i>Spartina patens</i> (Ait.) Muhl.	9
<i>Symphyotrichum subulatum</i> (Michx.) Nesom	4
<i>Symphyotrichum tenuifolium</i> (L.) Nesom	5
<i>Symphyotrichum turbinellum</i> (Lindl.) Nesom	4
<i>Thelypteris palustris</i> Schott	7
<i>Typha domingensis</i> Pers.	3
<i>Typha</i> L.	2
<i>Vigna luteola</i> (Jacq.) Benth.	3
<i>Websteria confervoides</i> (Poir.) S. Hooper	